L&T – IHI CONSORTIUM

CONTRACT AGREEMENT

between

MUMBAI METROPOLITAN REGION DEVELOPMENT AUTHORITY

and

L&T-IHI CONSORTIUM

(M/s LARSEN & TOUBRO LIMITED & M/s IHI INFRASTRUCTURE SYSTEMS CO. Ltd.)

MUMBAI TRANS HARBOUR LINK PROJECT (MTHL)

PACKAGE-1

"Procurement of Mumbai Trans Harbour Link Project (Package-1),Construction of a 10.380 km Long Bridge Section (CH 0+000 – CH 10+380) across the Mumbai Bay including Sewri Interchange"

(JICA LOAN: Mumbai Trans-Harbour Link Project (I) ID-P255)

MADE ON 26TH DECEMBER 2017

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Package-1 L&T- IHI Consortium

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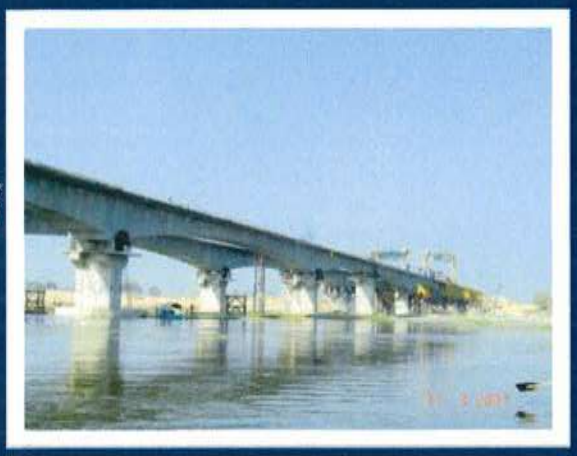
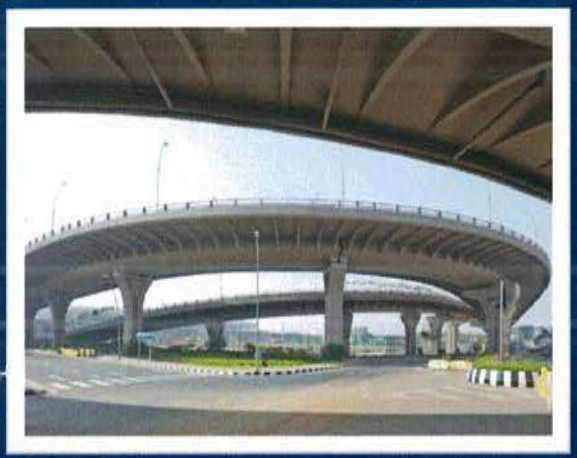
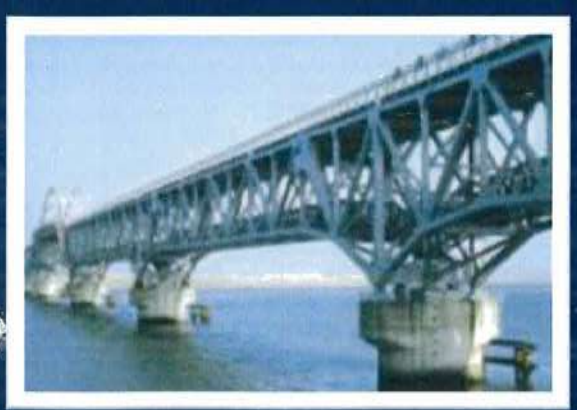






TECHNICAL BID ORIGINAL

VOLUME III

TEDNER SUBMISSION TO

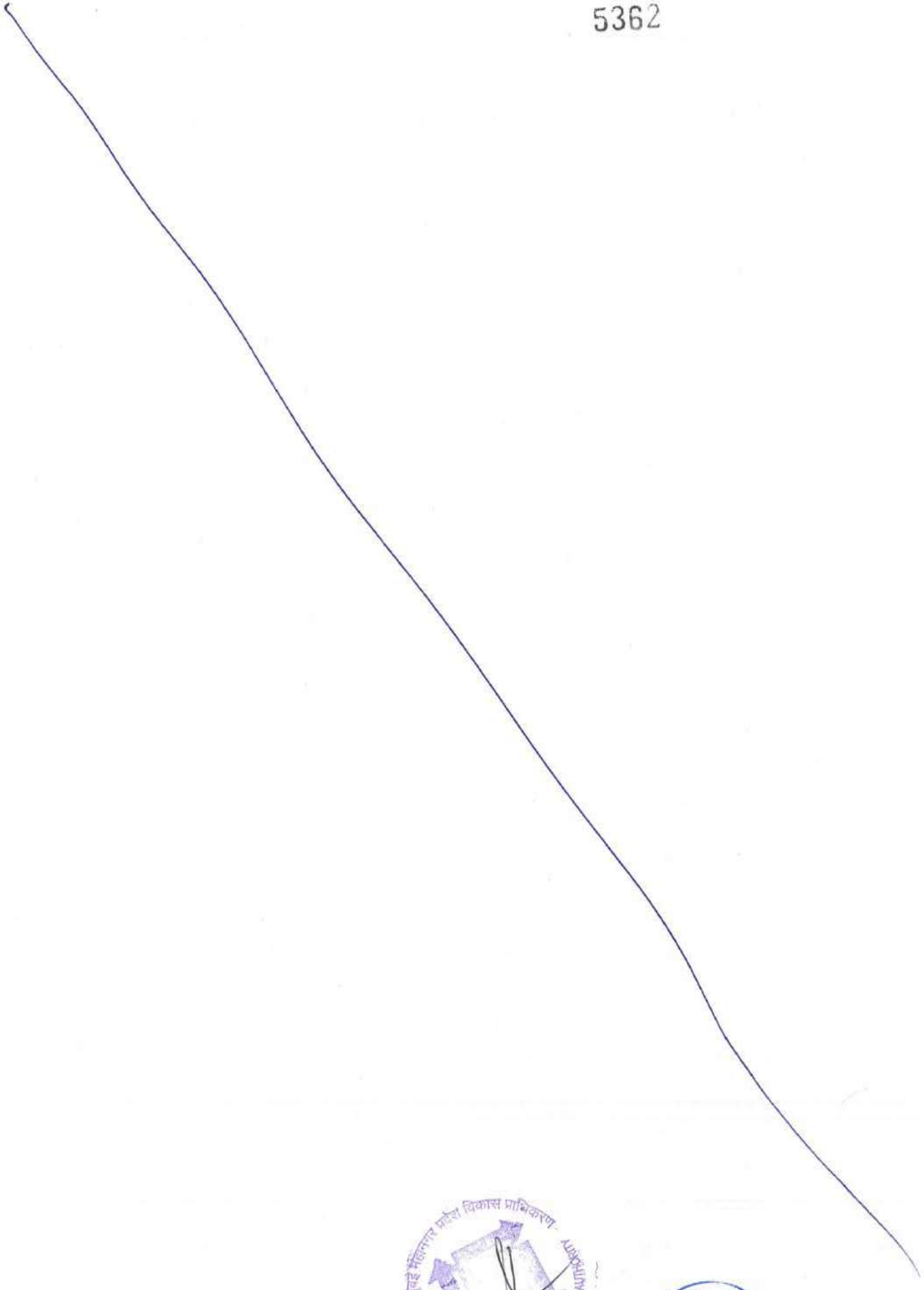
MMRDA

Package-1 (Construction of a 10.380 km long bridge section (CH 0+000– CH 10+380) across the Mumbai Bay and Sewri Interchange of Mumbai Trans Harbour Link Project

IFB No.:
MMRDA/ENG1/000752

L&T - IHI

July 2017

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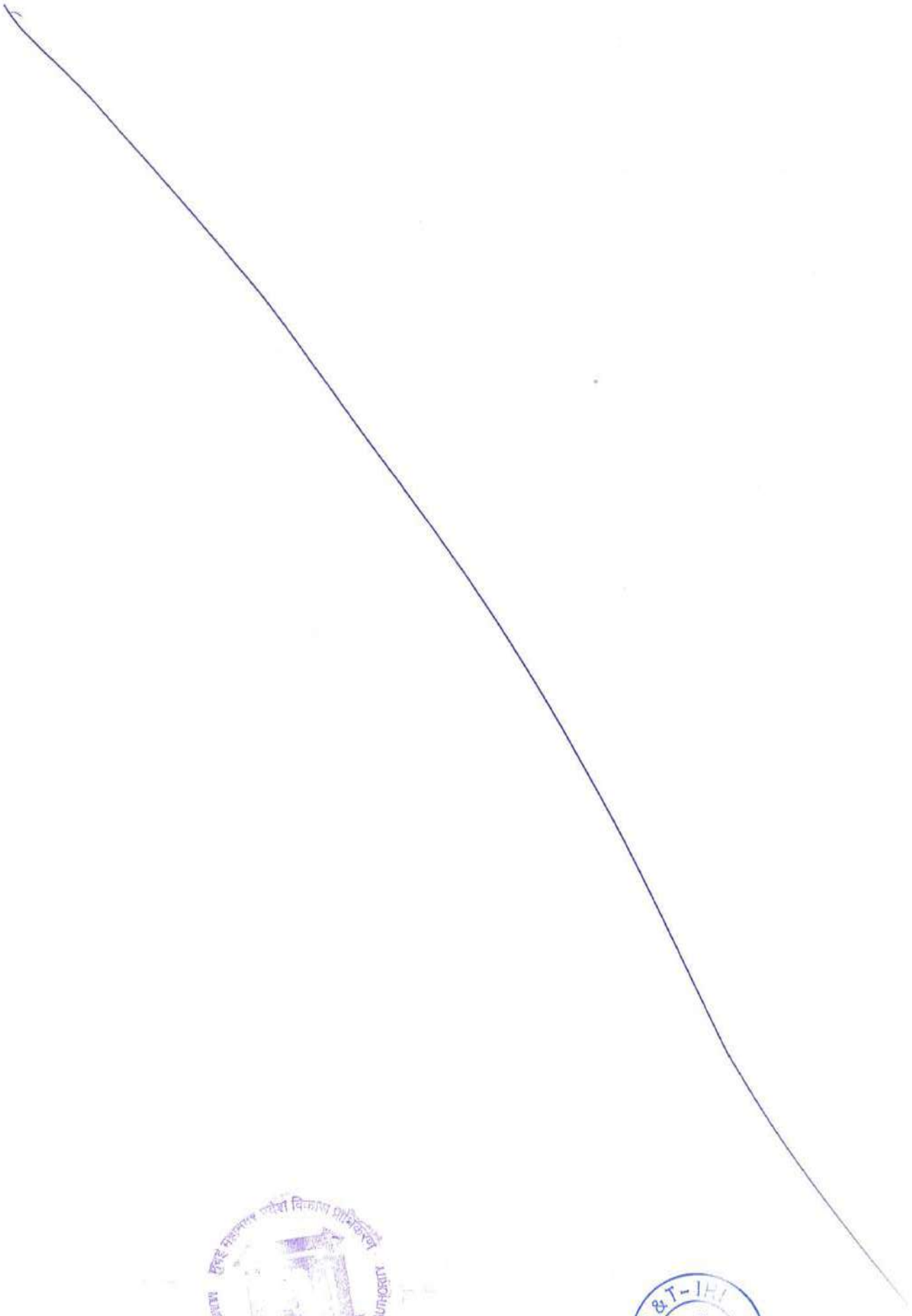

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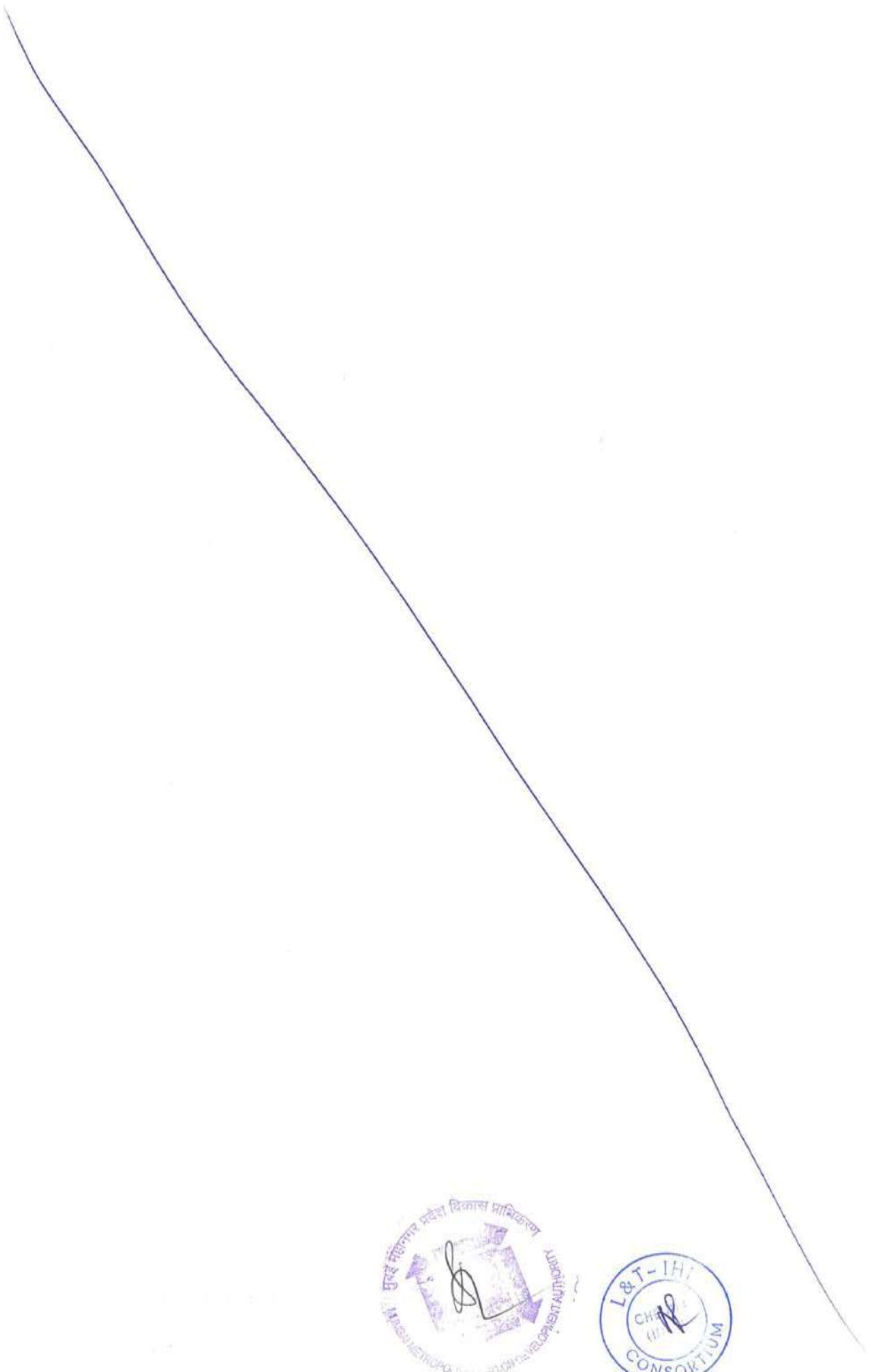


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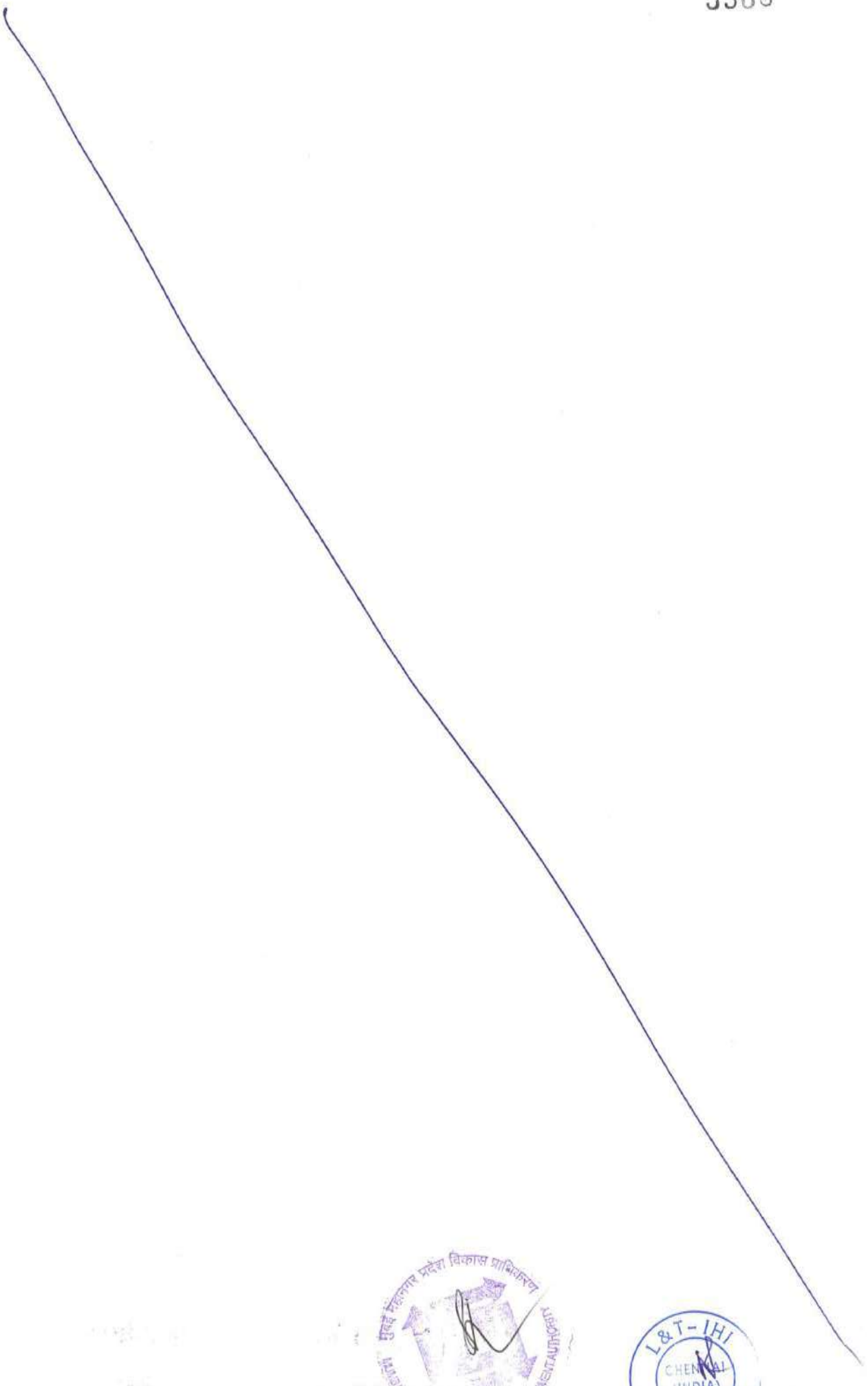

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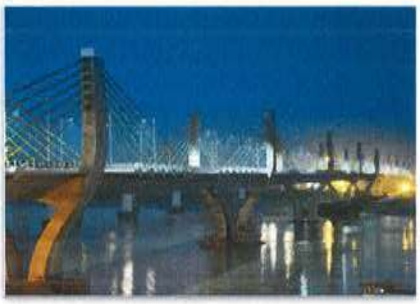

PRELIMINARY / BIDDING DESIGN

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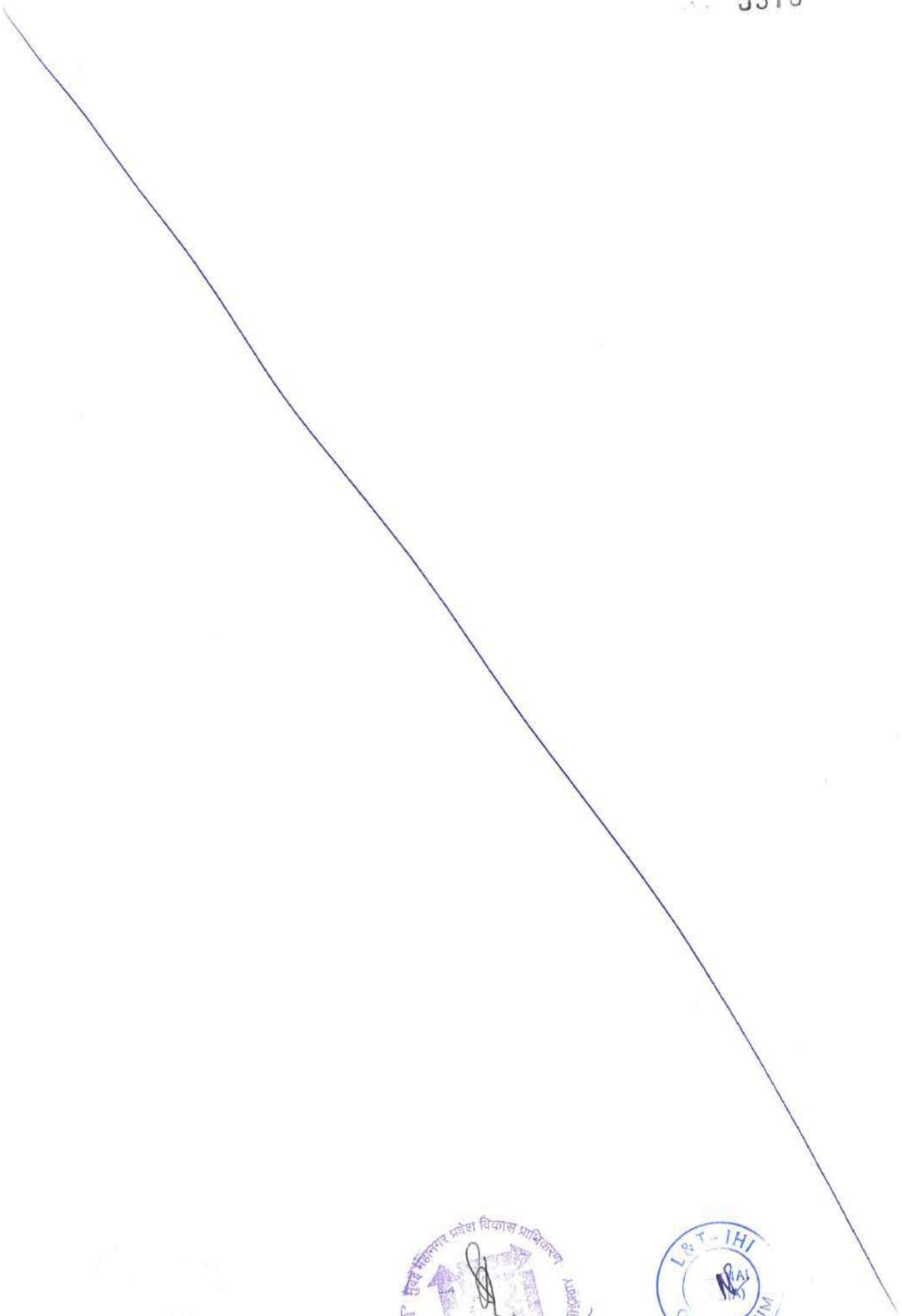

Note on Proposed Design Concept

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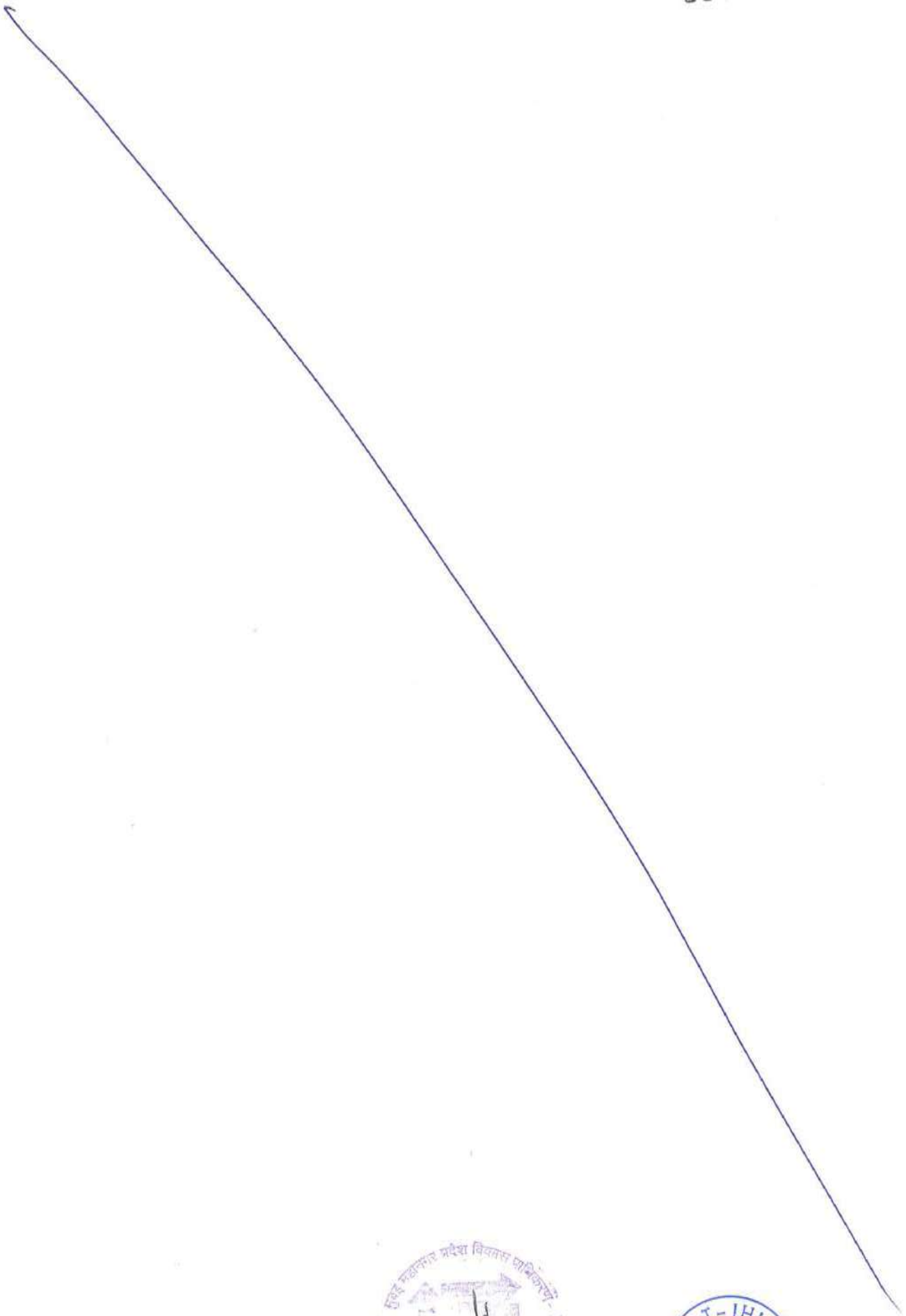


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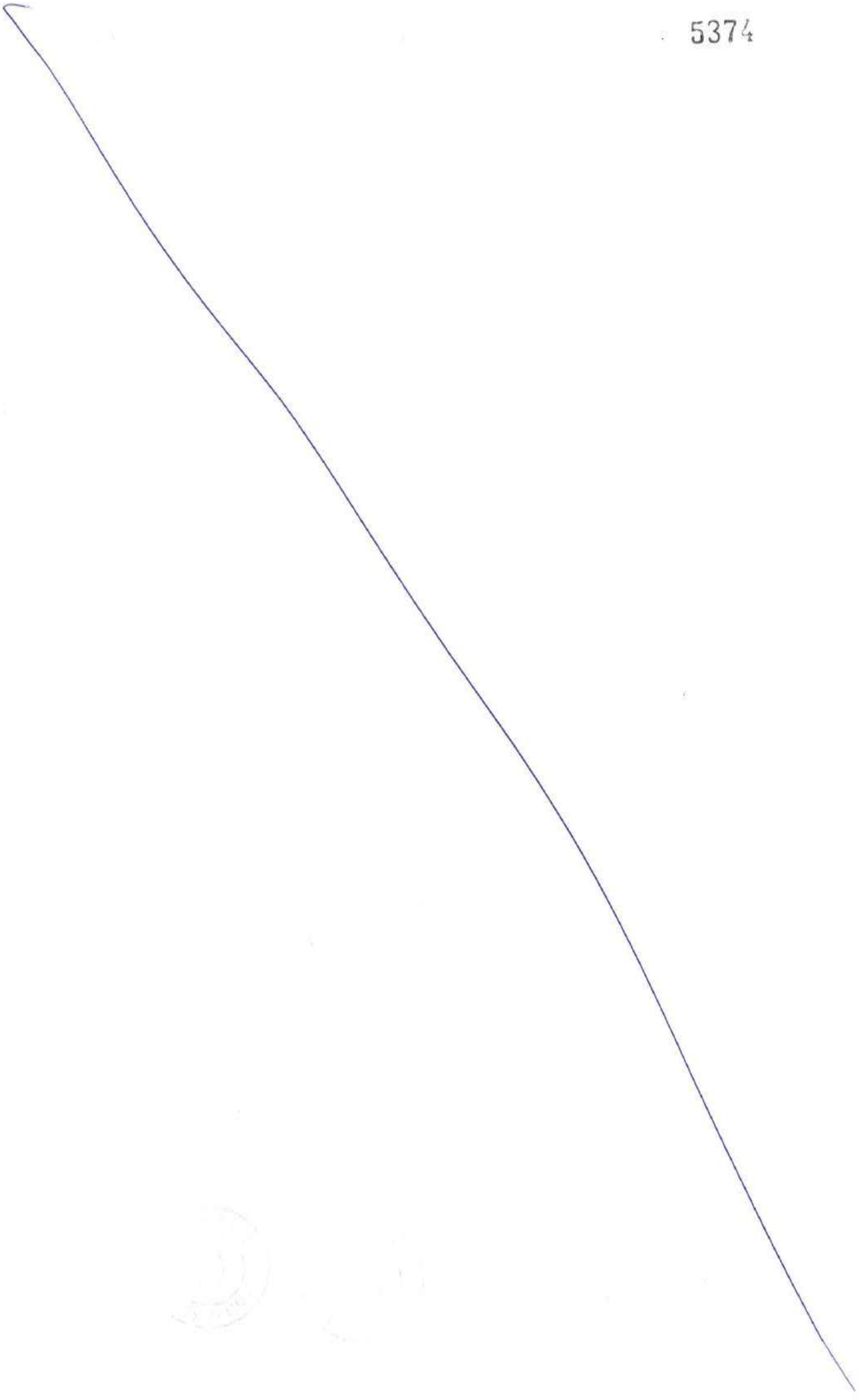


Note on Proposed Design Concept

1 Introduction

This document outlines considerations for the proposed design and in particular design difficulties/challenges. Comments and possible improvements to employer's requirements are likewise included.

2 Interchanges

2.1 Sewri Interchange

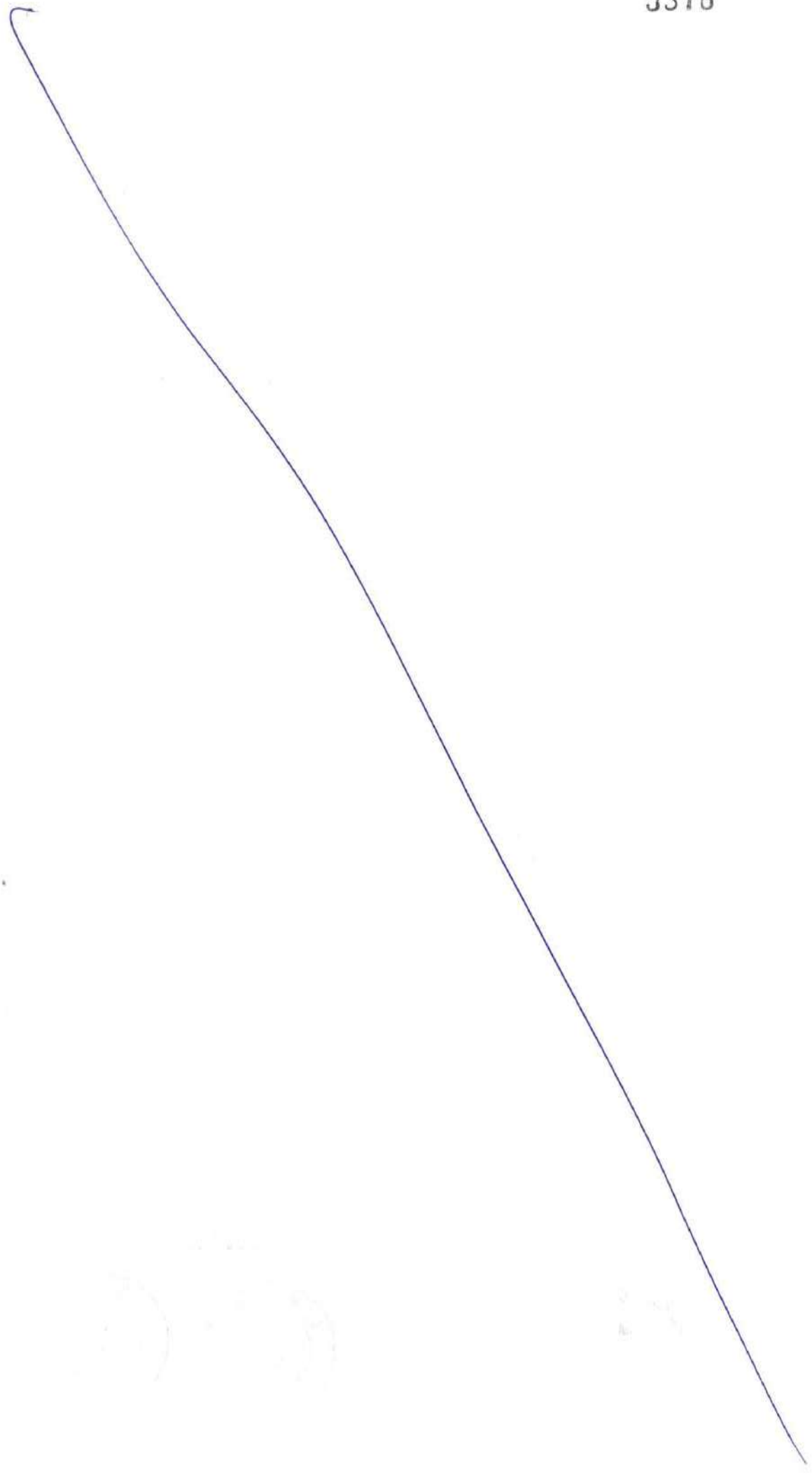
2.1.1 Design concept

The Sewri interchange has been designed to fulfil the employer's requirements (ER) and relevant standards. As such, the superstructure is longitudinally post-tensioned concrete box girders, whilst the substructure consists of rectangular piers with rounded edges and, typically, foundations with three piles.

In terms of structural efficiency, an effort has been made to reduce the amount of piles in the substructure and providing shared foundations, where possible. In addition, the superstructure has been made continuous for 200m+ sections for both structural efficiency and compliance with ER. This will create a smooth riding experience for the users.

Furthermore, an effort has been made to homogenise span lengths for both structural efficiency and constructability

The alignment of ramps A and B have been moved downwards slightly to save material and reduce vertical gradients as much as possible, whilst still obeying the vertical clearance criteria.



2.1.2 Design difficulties/challenges

The seismic design criteria have meant that the substructure is governed by the seismic loads. Hence careful consideration has been made to select a beneficial bridge articulation, which has resulted in elastomeric bearings. The relatively soft bearings minimise the force transfer to the substructure and thus allow material savings.

Another challenge was, and, is, the limited space available along the railway tracks parallel to the eastern freeway and proposed spans of ramp A. Here, the limited space has produced the need for as-slim-as-possible foundations.

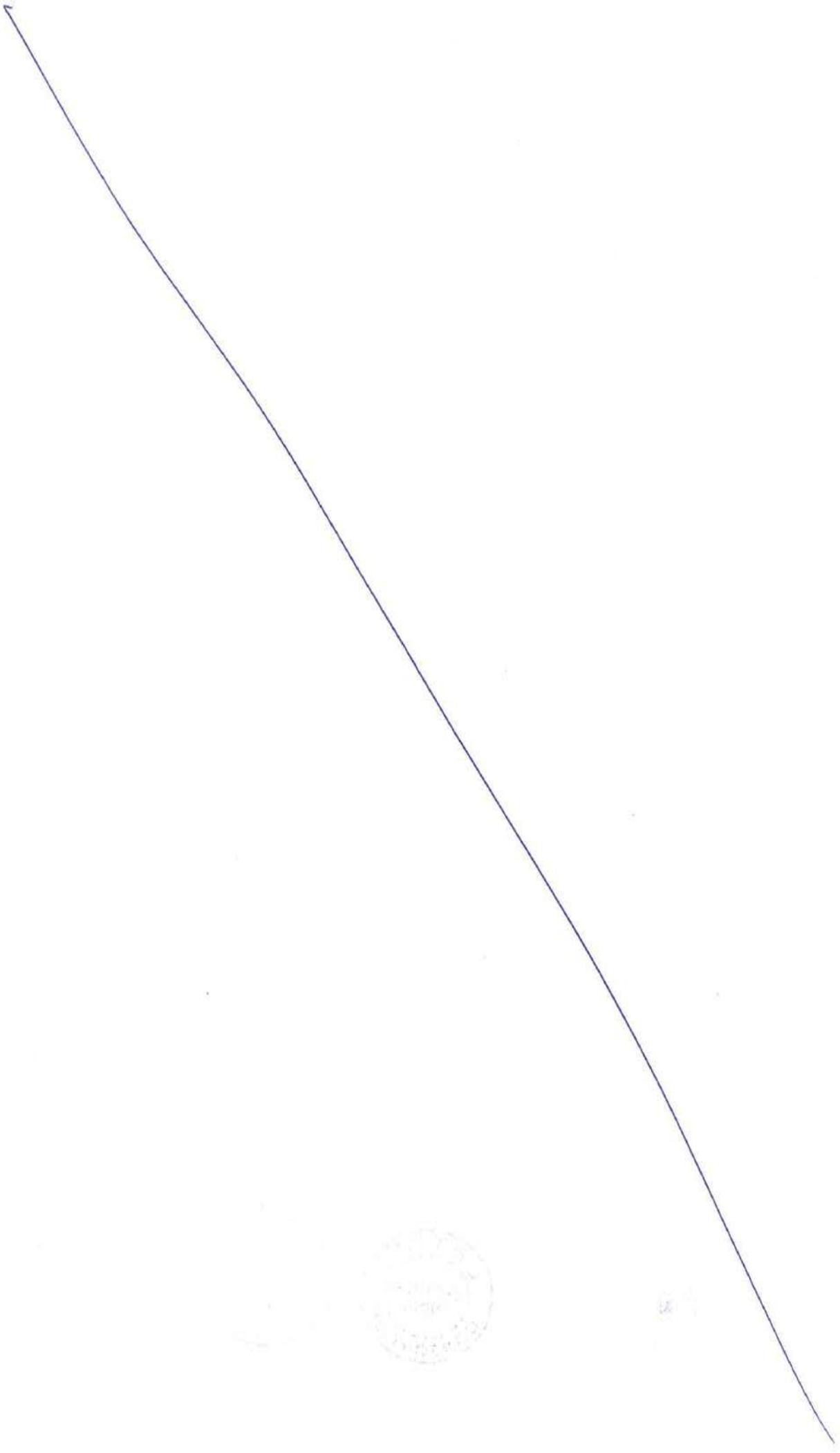
2.1.3 Comments to the ER

The ER requires a structurally efficient and aesthetically pleasing design. There is however an improvement to suggest, which could be to the benefit of the bridge owner; namely allowing monopiles, which will enable a reduction in foundation quantiles and area demand by avoiding use of pile caps in a very congested area.

2.2 Shivaji Nagar Interchange

2.2.1 Design concept

The Shivaji Nagar interchange has been designed to fulfil the ER and relevant standards. As such, the superstructure is hollowed slabs spanning, typically, 15m. The substructure consists of relatively slender piers shafts and pier heads with flare. Due to the quality of the soil conditions, piled foundations have been be omitted in favour of open foundations.



2.2.2 Design difficulties/challenges

The main structural challenges of the ramps are related to the seismic loads, which have produced the demand for as-slender-as-possible pier shafts. Relatively slender pier shafts will produce the lowest possible Eigen frequencies of the ramps, which in turn reduces the design governing seismic loads, thus minimising the necessary material in the substructure.

2.2.3 Comments to the ER

The ER requires a structurally efficient design of the interchanges. If a suggestion should be placed for modifications of the ER, then, as also stated in section 3.1.3 of the present report, the seismic loads could be re-considered, as they are the design driver for the substructure.

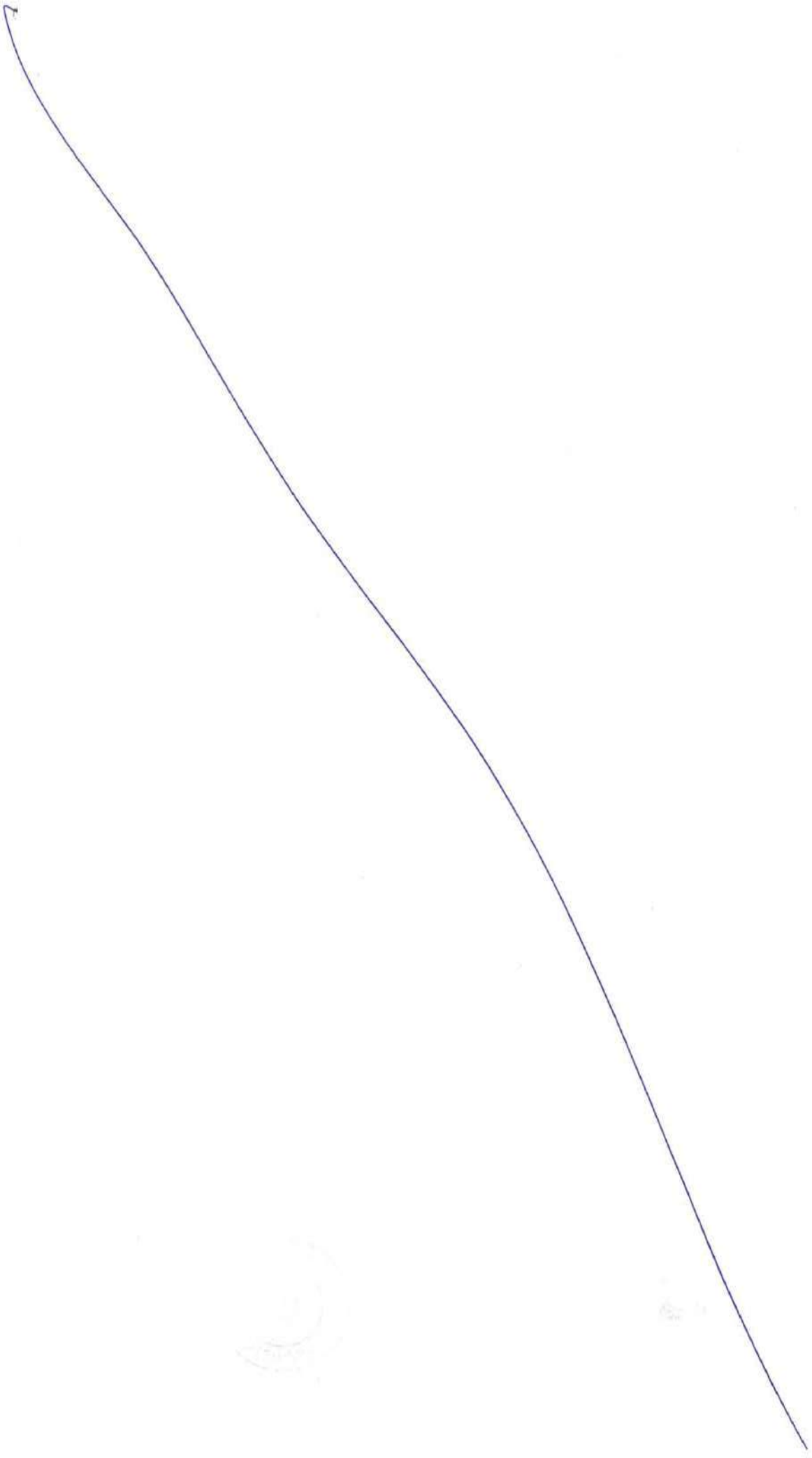
3 Concrete intertidal and marine viaducts

3.1 Superstructure

3.1.1 Design concept

For the marine viaducts and main viaduct at land section, chainage 0+495 to 18+187 the superstructure consists of two parallel concrete box girders and is erected using precast segmental span-by-span construction. The girder depth is 3.85m and have typical span length of 60m. To accommodate the fixed distances between steel bridges a limited number of spans are made shorter and placed at the approach span closest to special steel bridge navigation spans.

The box girders accommodate the 13.75m wide three lane carriageway by having 3.0m long cantilevers and 7.65m distance between the outside of the inclined webs.



Note on Proposed Design Concept

The width of the bottom slab is 6.0m as required to provide space for bearings, anti-dislodgement device and space for temporary jacks for bearing replacement. The inclination of the webs are 1-in-2.5.

The geometry of the box girder is shown on Figure 3-1.

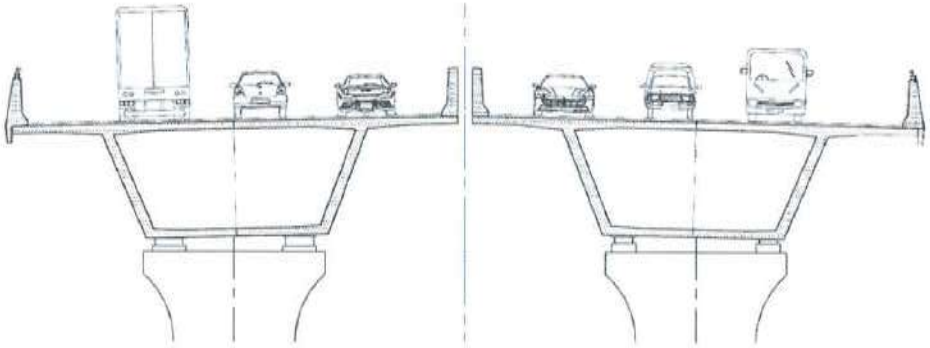
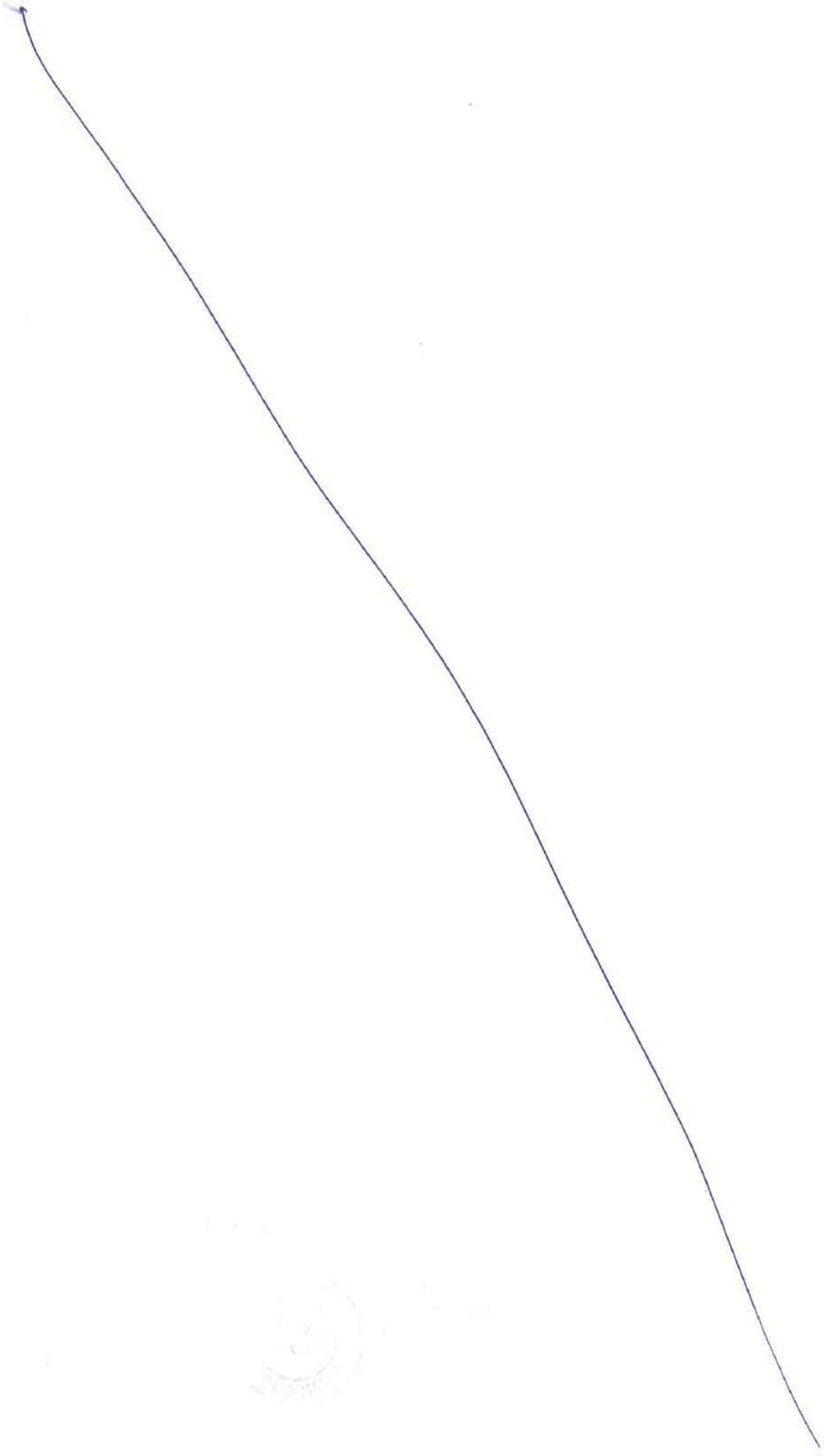


Figure 3-1Marine Viaducts – twin deck box girders

The box girder is post-tensioned with a combination of internal and external tendons. Internal tendons consisting of epoxy coated strand tendons are provided in bottom slab and deck slab. The external tendons consisting of zinc coated, greased and sheathed strand tendons are carried between diaphragms at piers and deflected at deviators in span. The tendons are stressed in two stages with internal tendons stressed in first stage and external tendons stressed in second stage.

The deck is made continuous over a length of typically 420m equal to seven 60m spans. The bearings are of elastomeric laminated type with shore hardness 60. The bearings accommodate irreversible and reversible movements under shearing of the rubber layers. The anti-dislodgement device is limiting the relative movement between pier and deck to the capacity of the bearings. The anti-dislodgement devices are in this respect provided as an additional safety against dislodgement of the deck.



The design of the precast segmental post-tensioned box girder shall be verified to applicable Indian standards and Employer's Requirements.

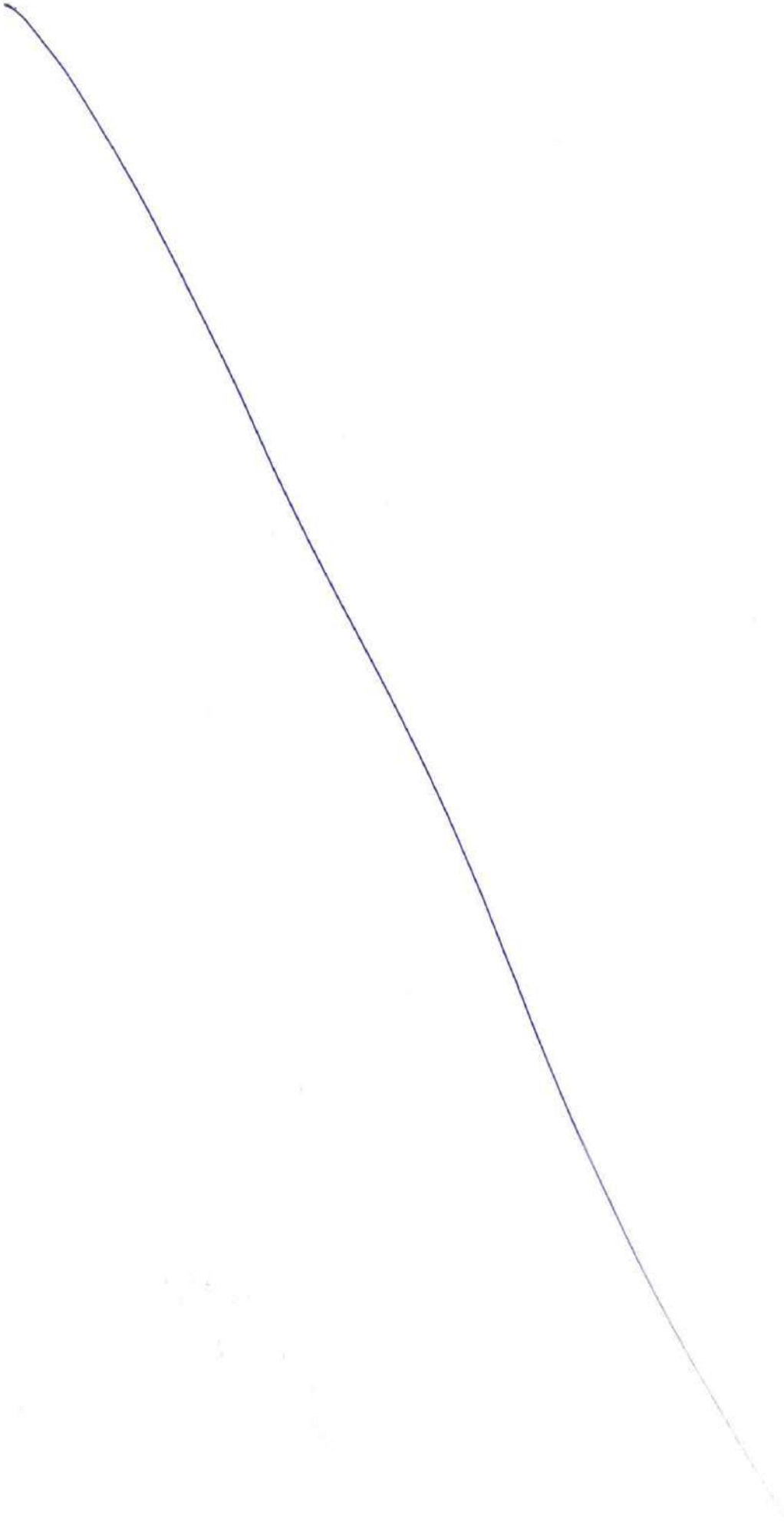
3.1.2 Design difficulties/challenges

The prescribed seismic design has two levels of seismic action. The MCE (maximum considered earthquake) is a factor two higher than the OCE (Operating Basis Earthquake) considered earthquake. Both earthquakes have to be considered with a load combination factor of 1.5. The level of seismic action is considerable and seen as a challenge for the design of marine viaducts. For this reason the articulation of the viaducts have been selected using elastomeric laminated bearings resulting in a flexible response under seismic action. A flexible response is advantageous as the developed seismic forces in a flexible system will be less than for a more rigid system.

The flexibility is mainly provided by the bearings that act in shear under seismic action. The shear deformation in the rubber is limited to the design value at which point the anti-dislodgement devices would prevent further deformation over and above the design value arising from excessive seismic action.

To prevent relative movement in the transverse direction (perpendicular to traffic direction) at expansion joints a horizontal shear key has been introduced between the two bridge ends at expansion joints. The shear key has to accommodate longitudinal movement while carrying transverse forces due to e.g. buffeting wind and dynamic forces in case of seismic action. The shear key is therefore provided with elastomeric bearings with sliding plates either side of the key.

The selected articulation is considered to provide the most efficient solution for carrying the challenging MCE earthquake.



3.1.3 Comments on the Employer's Requirements

The ER is considered to be well prepared and providing for the bidder to develop a design that is both efficient and at the same time robust.

The ER is considered ambitious with regard to seismic design. The introduction of the MCE earthquake and at the same time maintaining a load factor of 1.5 is equivalent to a significant increase in the return period of the seismic action in comparison with traditional seismic design to IRC:6.

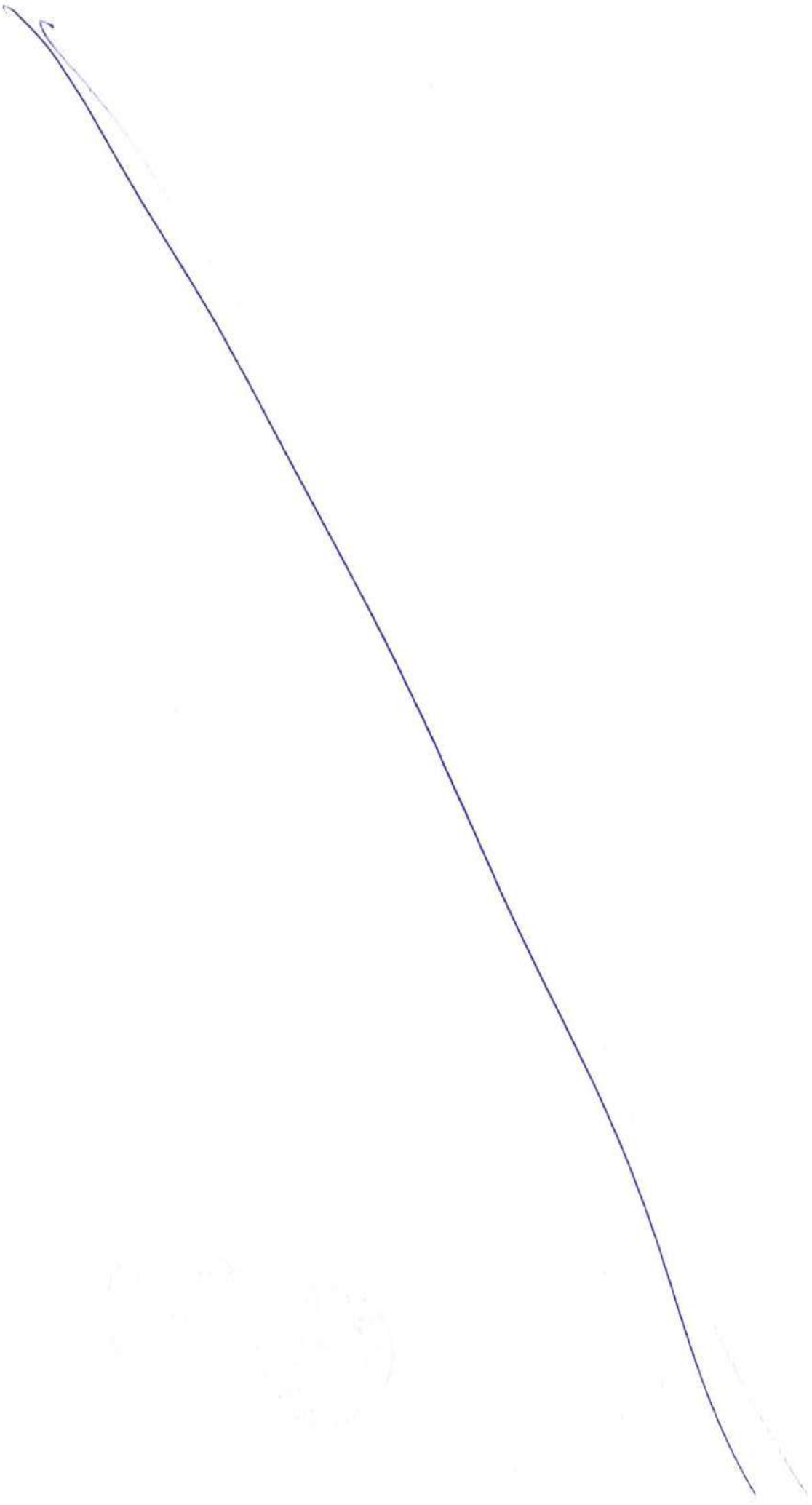
It is further required that the design is developed in detailed design considering site specific response spectrum. In this respect it would be relevant to define the return periods to be considered for the two levels of seismic action.

3.2 Substructure

3.2.1 Design concept

Foundations:

For the marine viaducts and main viaduct at land section , chainage 0+495 to 18+187 the foundation consists typically of a common pile foundation for both carriageways as shown on Figure 3-2 below. Four 2.2m diameter piles are used with two piles placed centrally below each girder and interconnected by a pile cap of variable width. The pile caps have rounded and bottom level is at +6.0m.



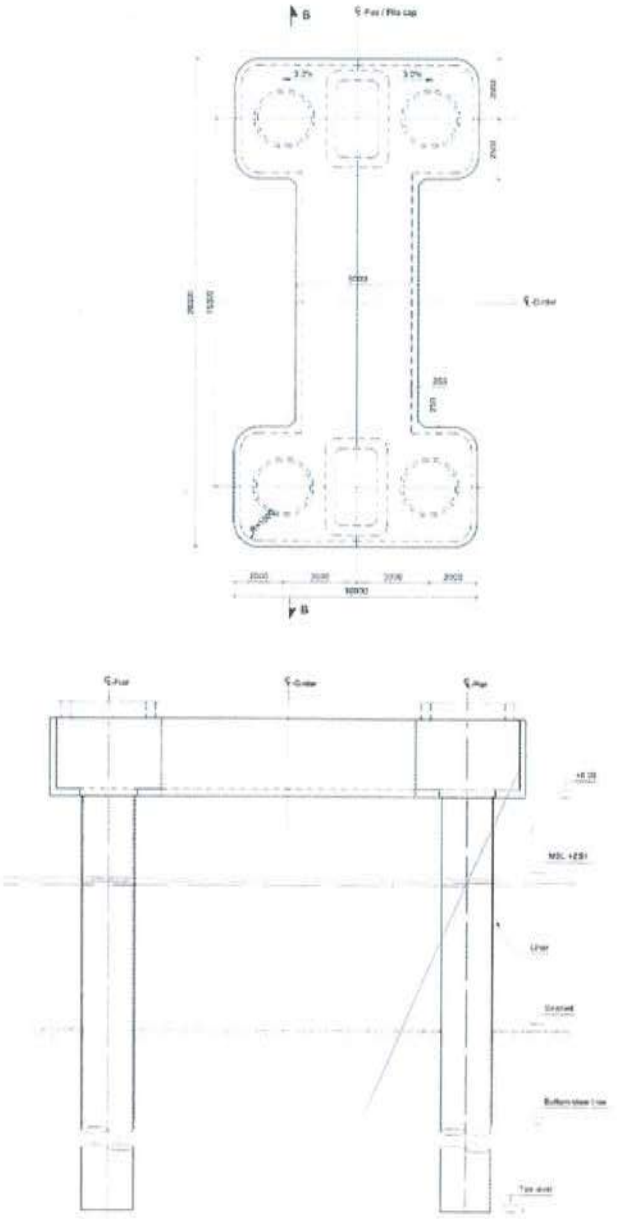
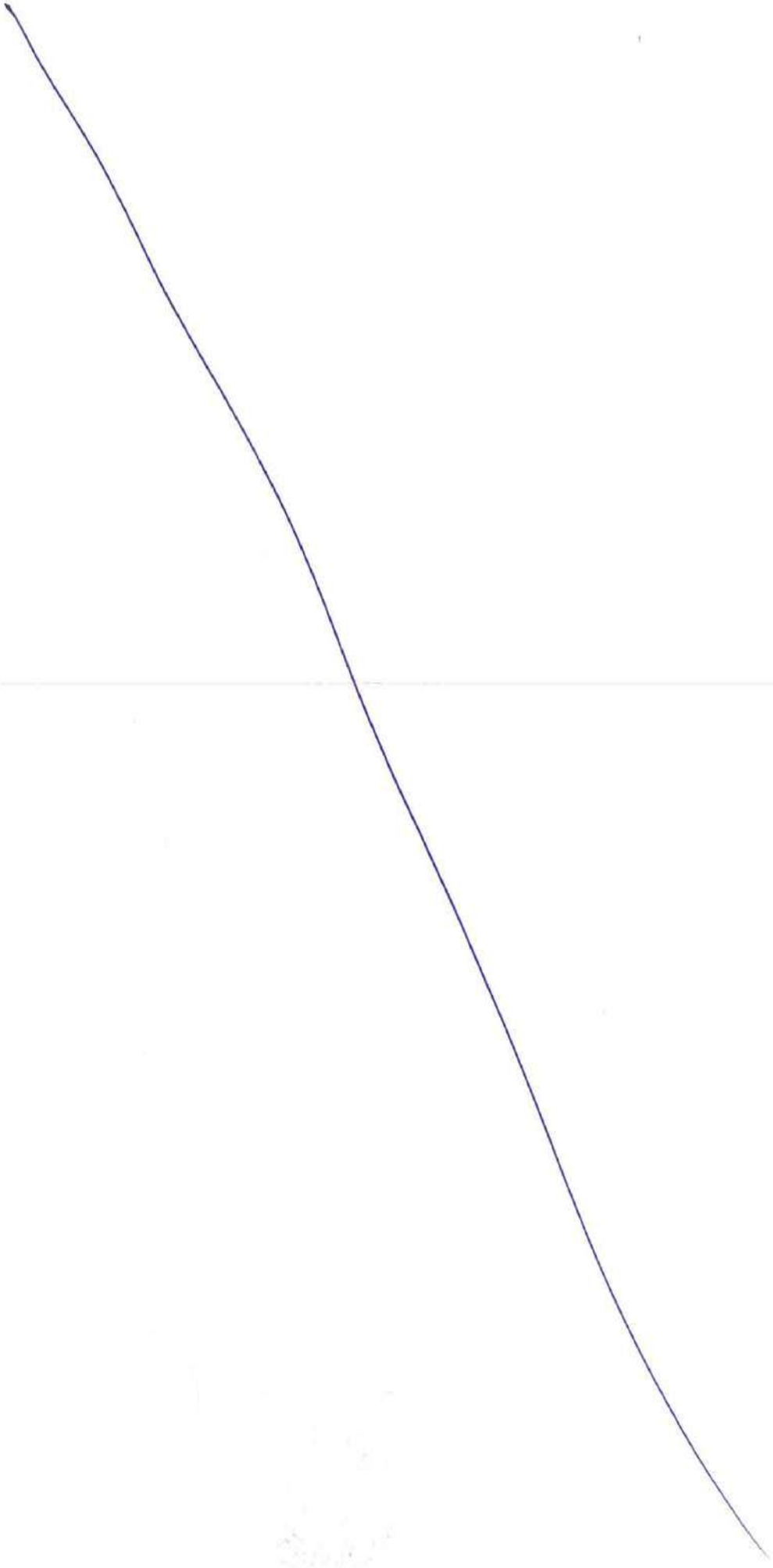


Figure 3-2 Marine Viaducts – pile foundations

The piles are bored concrete piles using liner of 16mm thickness, which is not used for structural purpose.

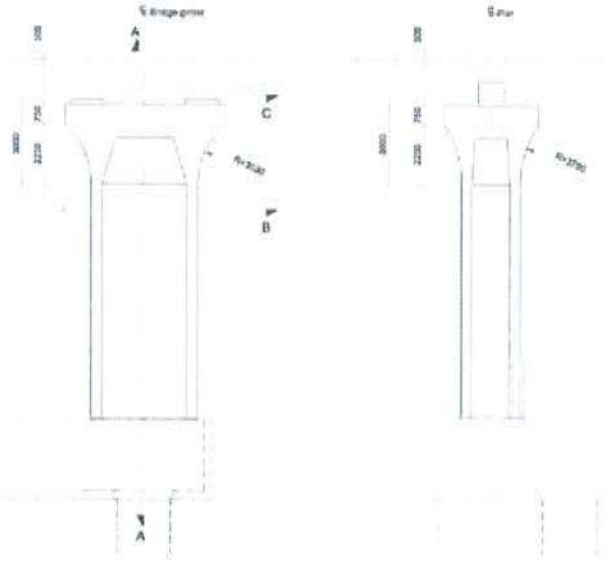


Note on Proposed Design Concept

The pile caps are constructed by casting concrete in-situ within a pre-fabricated concrete box (PC-house) placed on top of the piles by crane. The PC-house may be divided in say three parts which are connected by concrete stitches cast in-situ if it is desired to reduce the lifting weight.

Piers:

The pier shafts have rectangular cross section with rounded corners as shown on Figure 3-3 below. The pier head is widened in both directions in order to provide space for bearings and anti-dislodgement devices. Also space for temporary jacks in case of replacement of bearings is taken into account. The widening of the pier heads follows a circular curve and grooves are provided for improved appearance.



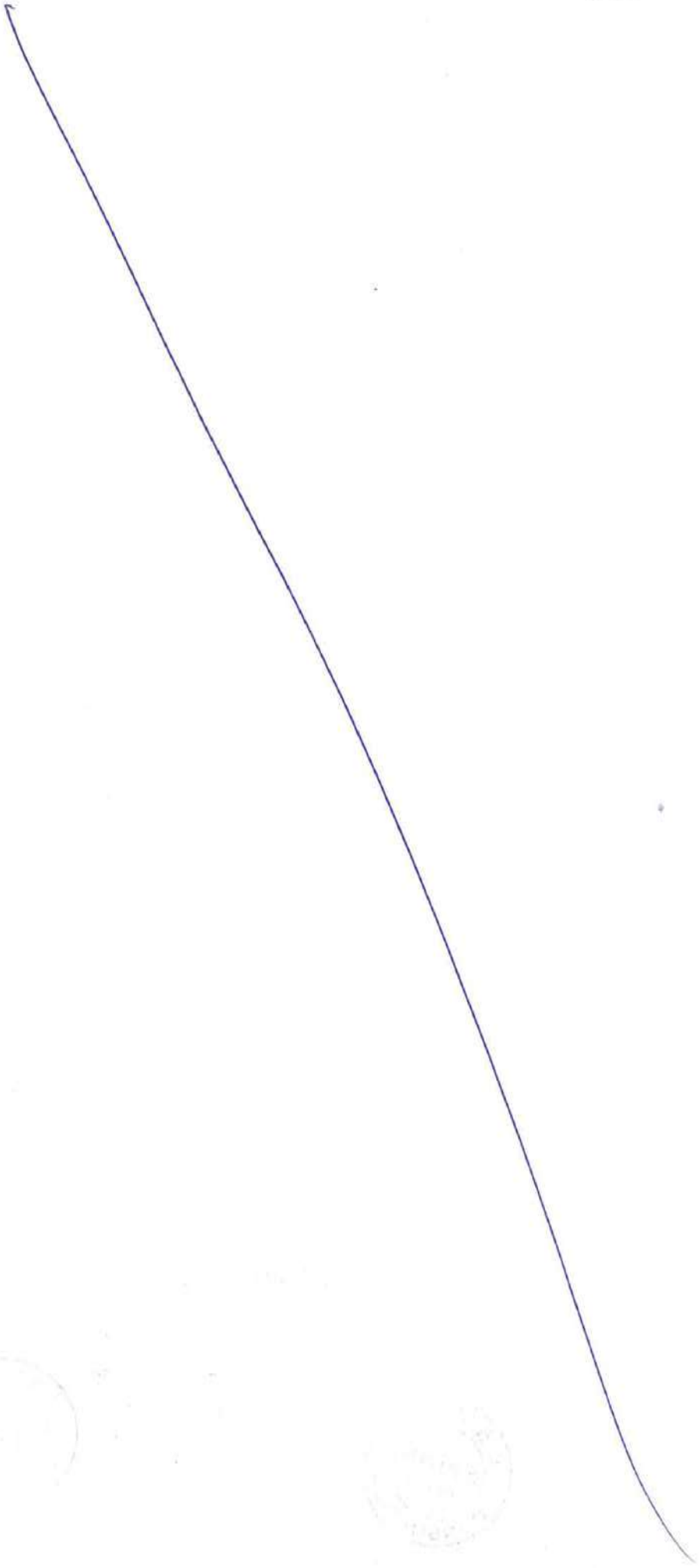


Figure 3-3 Marine viaducts – piers

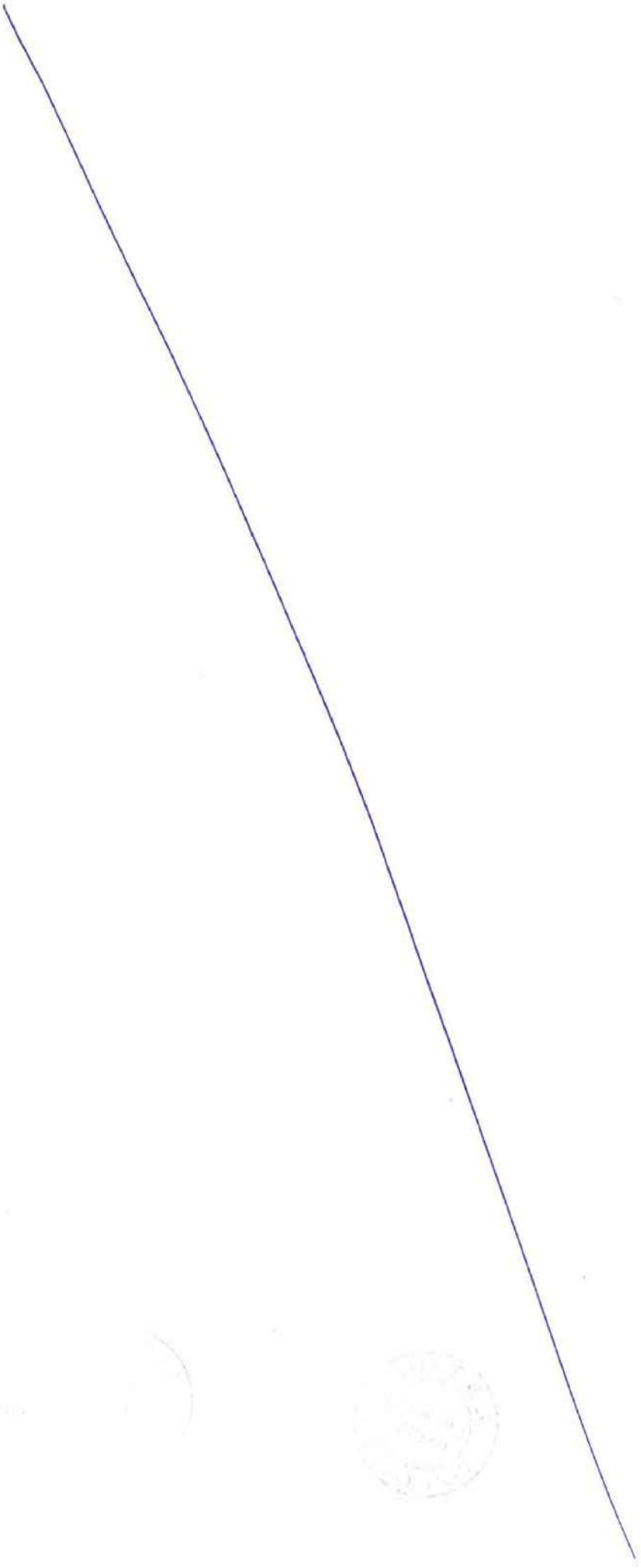
The piers are constructed in-situ using climbing form.

3.2.2 Design difficulties/challenges

The first important design challenge for the foundations is the seismic loads. Generally the foundation design is governed by the MCE earthquake requirements. Therefore, the design challenge is to a large extent to find solutions to reduce the seismic response for the foundations.

In the tender design the solutions adopted to reduce the seismic response on the foundations are introduction of elastomeric laminated bearings and slender piers. This tends to increase the fundamental periods of vibration of the structures resulting in lower response when designing according to elastic response spectrum method as shown in IRC:6-2014. If a more rigid articulation system were e.g. based on using integral connections between piers and girders then the seismic response would increase considerable creating higher demands to the foundation design.

The second important design challenge is vessel impact. A summary of design methodology for vessel impact including collision forces used for the tender design is provided in the vessel impact report. Based on the collision force considered for the



marine viaduct bridges it has been determined that a pile diameter of 2.2m is required to achieve the structural capacity needed of the pile being directly hit.

3.2.3 Comments on the Employer's requirements

Based on the two important design challenges described above the following comments are noted.

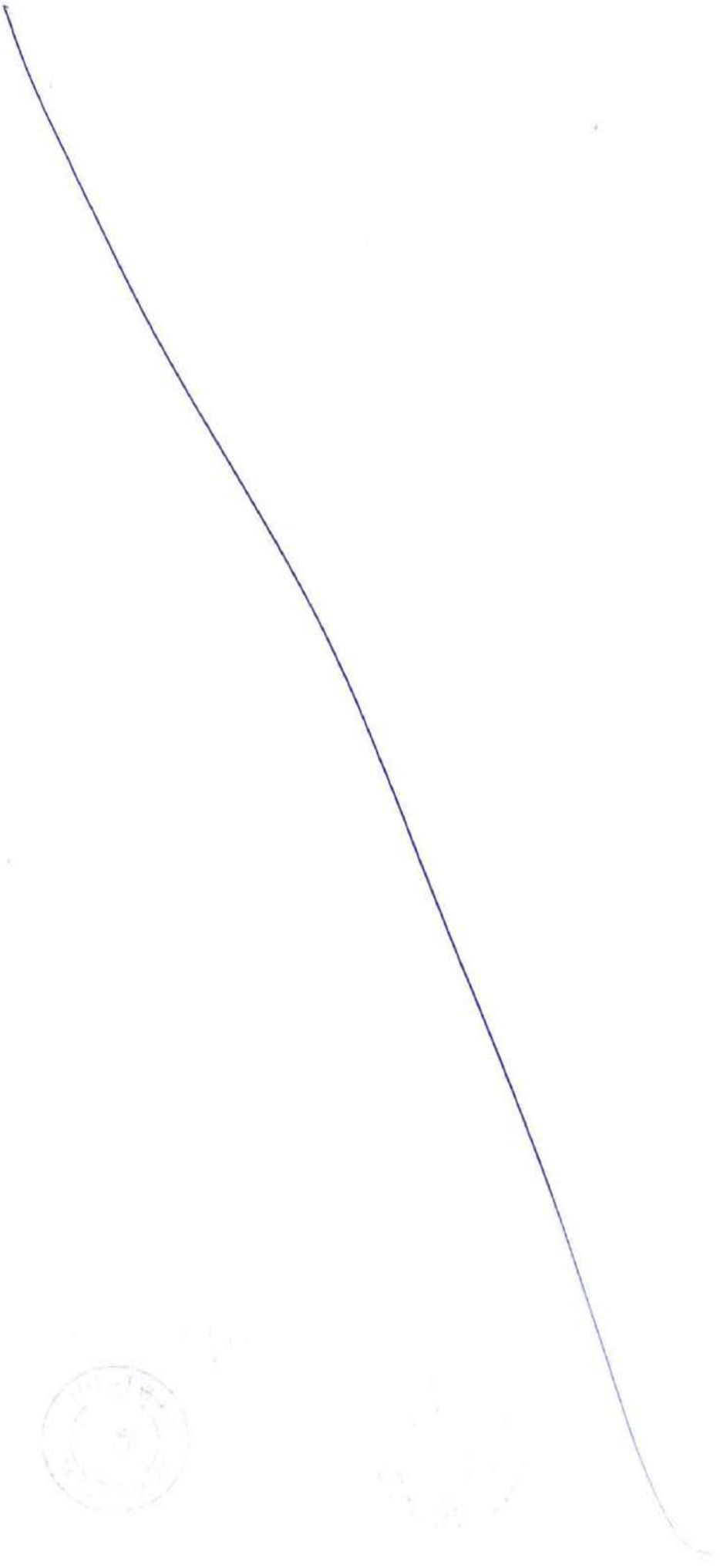
The requirements in relation to seismic design specified in the Employer's requirements result in considerable increased demands to the foundation design as compared to the seismic design rules directly according to IRC:6-2014.

The requirements in relation to vessel impact specified in the Employer's requirements specifies that, quote.

For all marine piers other than those adjacent to the navigational spans, the structure shall be designed for at least the minimum vessel impact forces more stringent out of IRC-6 or AASHTO guidelines (probabilistic method).

All those piles which for marine piers which are exposed with sufficient freeboard to allow accidental impact from a barge and located in sufficiently deep waters for laden barges as per IRC-6, shall be designed and detailed for protection against all probable structural damages.

The probabilistic method according to AASHTO guidelines required information on types and numbers of vessels plying in the area, sailing pattern and evaluation of possible future developments etc. As no such data are available at this stage the minimum vessel impact force has been assessed based on IRC 6 waterway I as explained in the vessel impact report. In detailed design the impact force according to



AASHTO guidelines shall be determined. If this force exceed the current assessment in the tender design this may have a direct impact on the required pile diameter.

In order to reduce the risk in relation to vessel impact on the piles it is proposed to change the requirement for the level of the pile cap currently requiring bottom level at +6.0m to +6.0m at the top as specified for the obligatory spans.

This would also result in a more harmonious appearance of the project.

4 Steel bridges

4.1 Superstructure

4.1.1 Design concept

The steel bridges are located in the crossing category "Special Section (marine area)". The steel bridges cover 4.063 km of bridge at four sections of the crossing. The span arrangement and bridge names are shown in the table below.

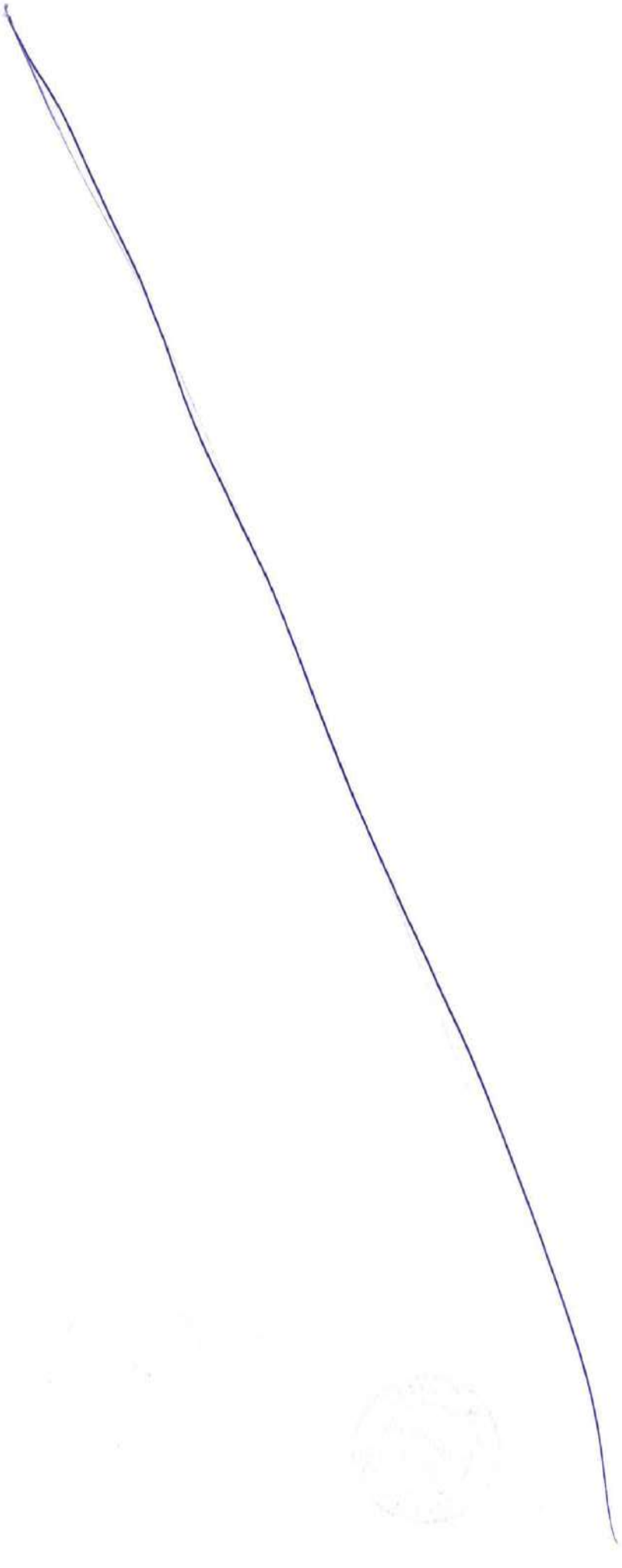


Table 4-1: Steel bridges span arrangement

	Sl.No.	Bridge Chainage (km)	Bridge location	Bridge Name	Bridge Span/ Length in metre
Package -1	1	3+395 to 3+715	Tata Thermal Power Station Intake & Discharge Channel	Bridge P1-OS01 NS/SS	85m+150m+85m = 320m
	2	4+625 to 6+078	Tata Thermal Power Station Coal berth Channel	Bridge P1-OS02 NS/SS	90m+2@150m+2@100m+93m = 683m
	3		Tata BPCL Power Cables, Submarine Pipe & Pir-pau Jetty	Bridge P1-OS03 NS/SS	120m+180m+120m+140m+120m+90m = 770m
	4	8+620 to 9+180	Thane Creek Channel	Bridge P1-OS04 NS/SS	100m+2@180m+100m = 560m

	Sl.No.	Bridge Chainage (km)	Bridge location	Bridge Name	Bridge Span/ Length in metre
Package -2	1	11+880 to 13+610	ONGC and BPCL Pipelines / Panvel Creek Channel	Bridge P2-OS01 NS	84m+2@130m+180m+115m = 639m
	2			Bridge P2-OS02 NS	74m+4@95m+65m = 519m
	3			Bridge P2-OS03 NS	112+2@180m+100m = 572m
	1	11+880 to 13+610	ONGC and BPCL Pipelines / Panvel Creek Channel	Bridge P2-OS01 SS	98m+140m+150m+180m+90m = 658m
	2			Bridge P2-OS02 SS	55m+4@95m+65m = 500m
	3			Bridge P2-OS03 SS	100m+2@180m+112m = 572m

OS = Obligatory span
P1 = Package -1
P2 = Package -2
NS = Northside (from Mumbai to NaviMumbai)
SS = Southside (from NaviMumbai to Mumbai)

The steel bridges consist of two closed box steel girders separated by 500 mm. The typical bridge cross section is shown in Figure 4-1.

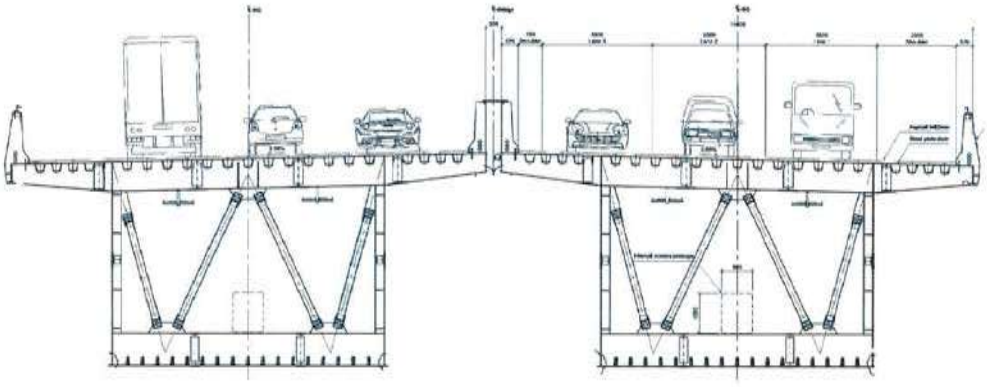
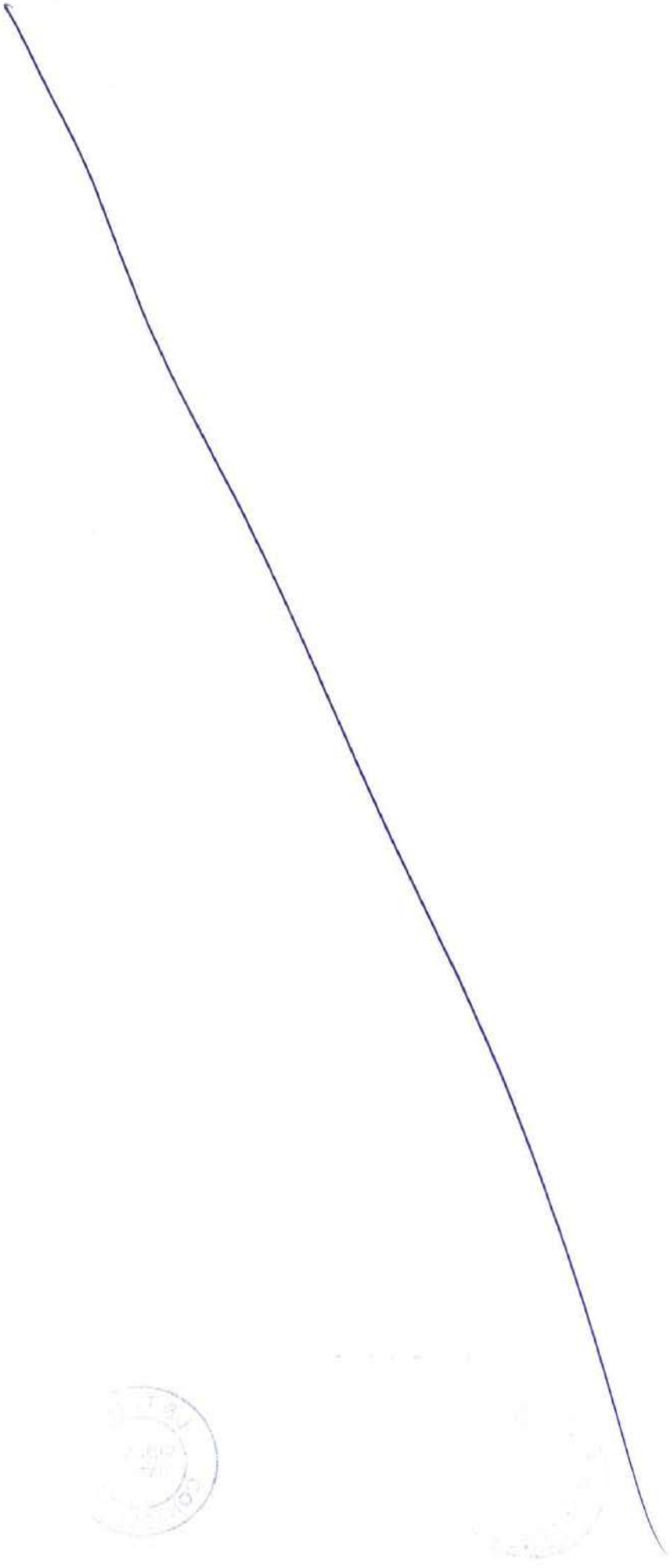


Figure 4-1: Steel bridge cross section

The depth of the girders vary between 3.3 m to 6.6 m and the girder depth varies significantly within the same bridge. The depth of the girder is typically approximately 1/30 to 1/22 of the span length. A relatively large girder depth is chosen, since high stiffness is required to satisfy the strict deformation criteria of L/500 according to [JRA



2002]. High stiffness is therefore also required towards the middle of the spans and therefore a haunched girder shape is not deemed suitable.

The typical bridge cross section with main dimensions is shown in Figure 4-2.

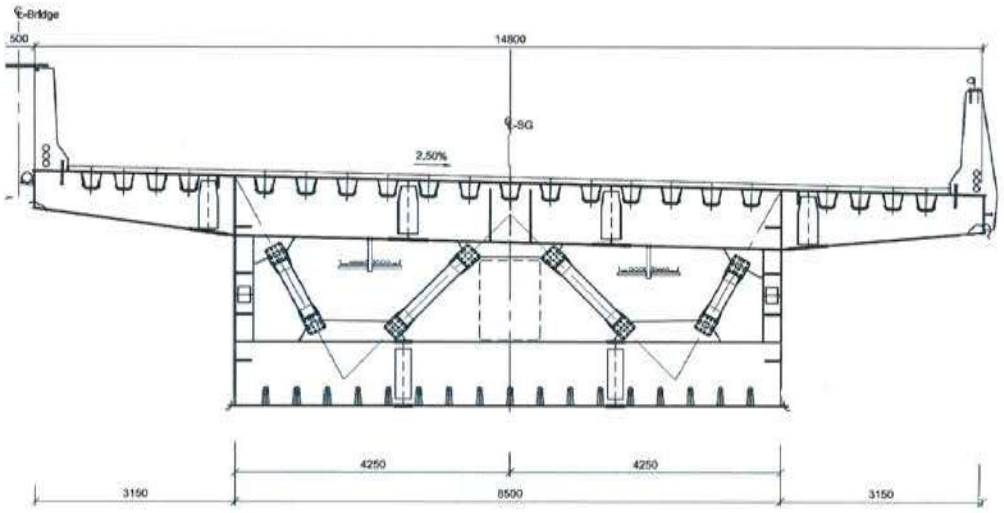
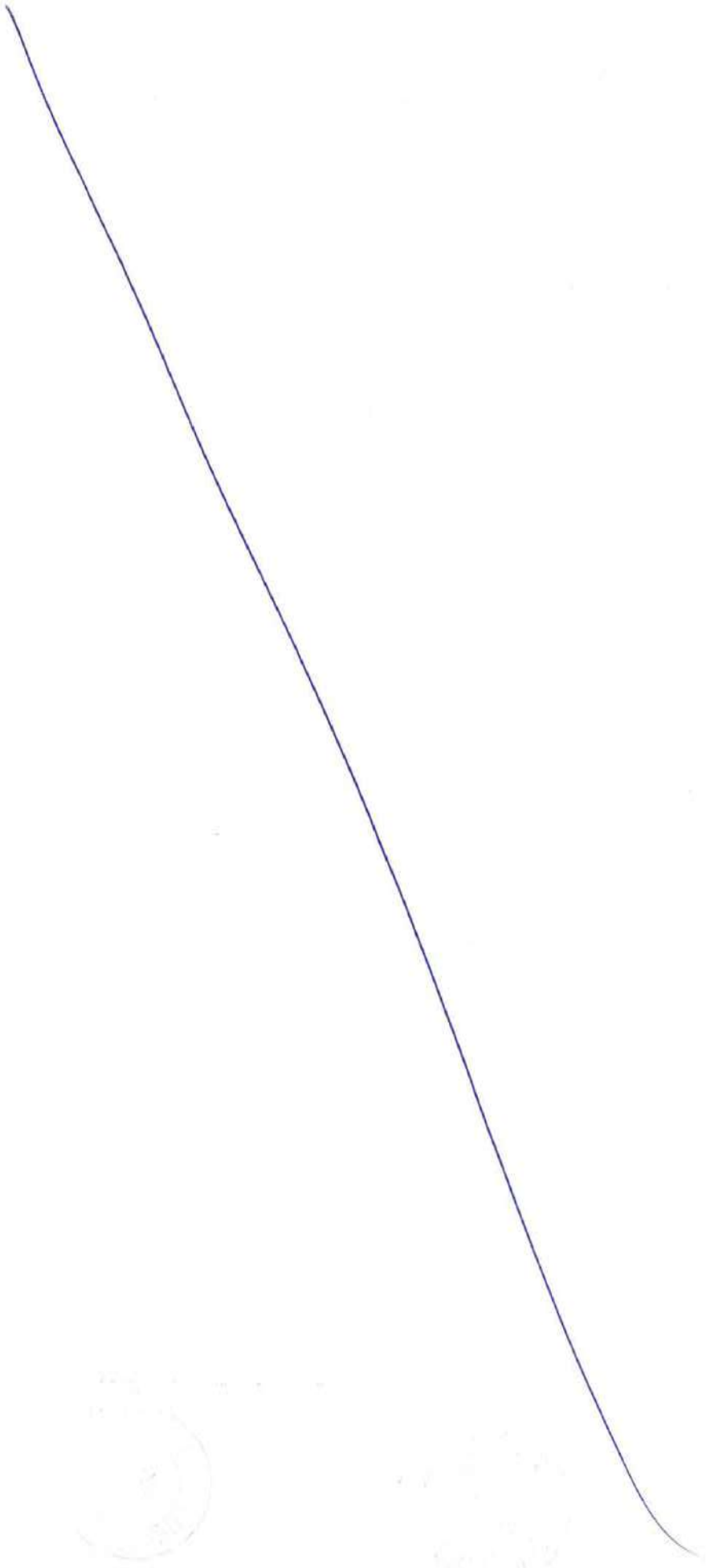


Figure 4-2 Girder cross section, south girder shown at location with shallow girder depth

The longitudinal steel of the bridge girders is shown in Figure 4-3.



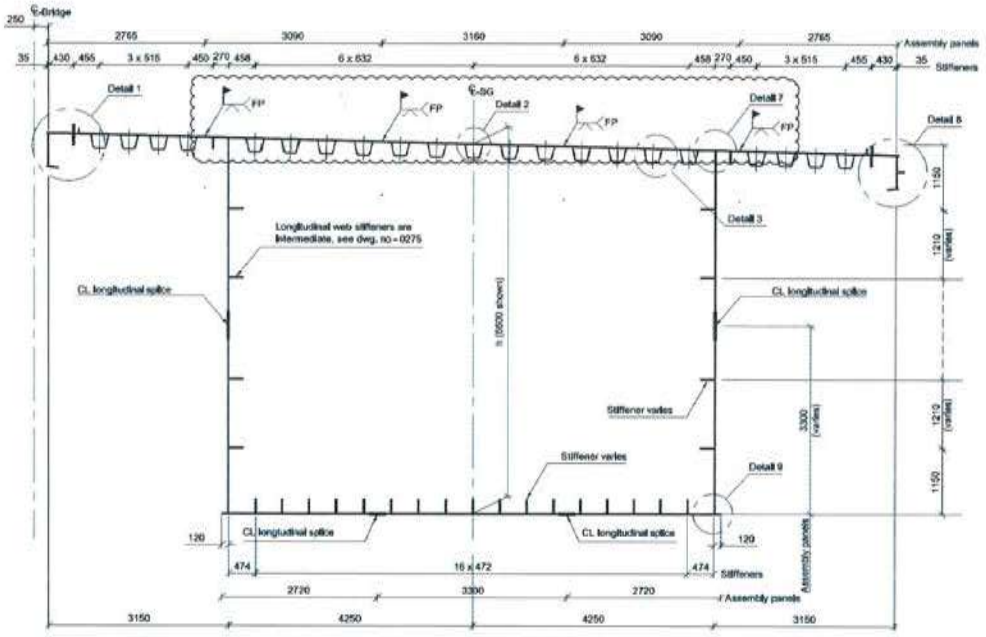


Figure 4-3 Girder cross section showing longitudinal steel only, south girder shown

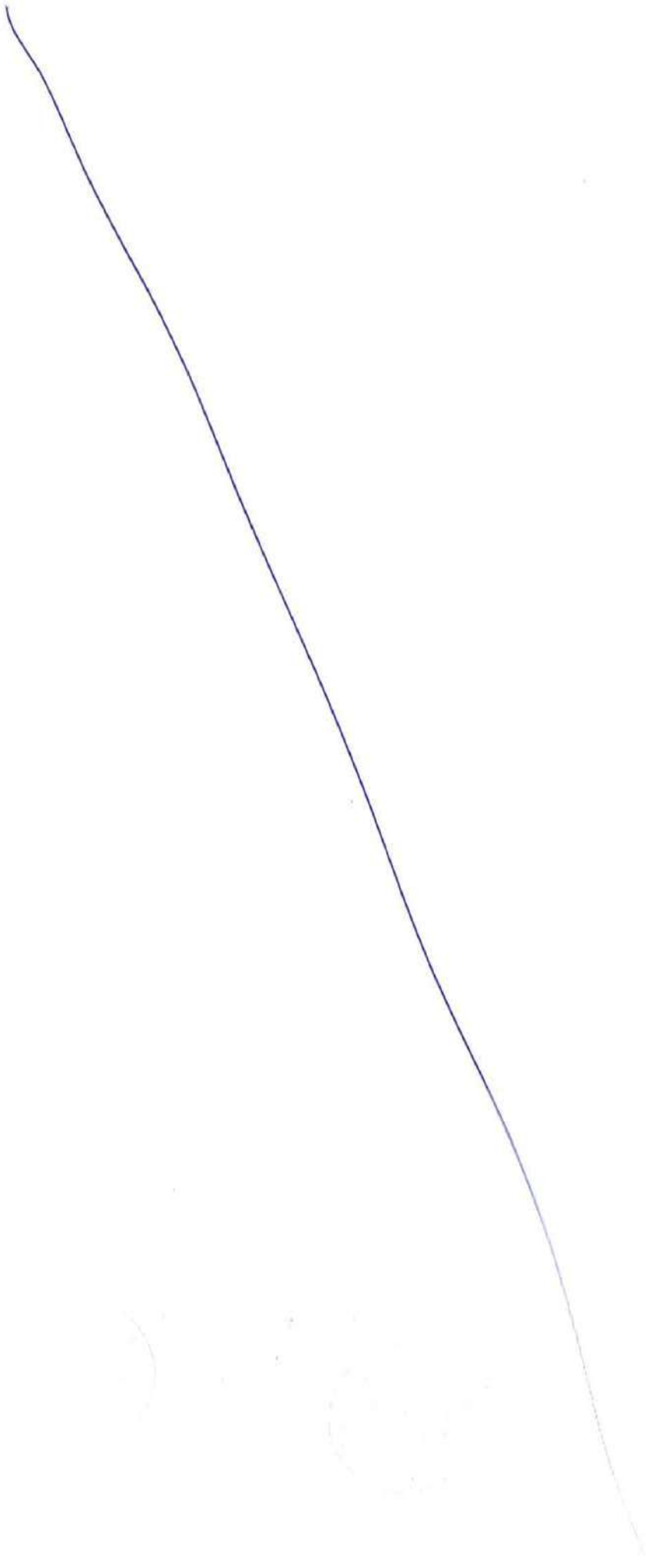
The longitudinal steel consists of following components:

- An orthotropic deck with a deck plate of minimum 16 mm thickness and stiffened by continuous trough stiffeners at approximately 600 mm transverse spacing. Some of the steel bridges have a small horizontal curvature, which means that the deck plate becomes slightly "skewed".

- Vertical webs stiffened by intermediate longitudinal flat stiffeners (horizontal stiffeners).

- A bottom flange stiffened by continuous flat stiffeners at approximately 500 mm transverse spacing.

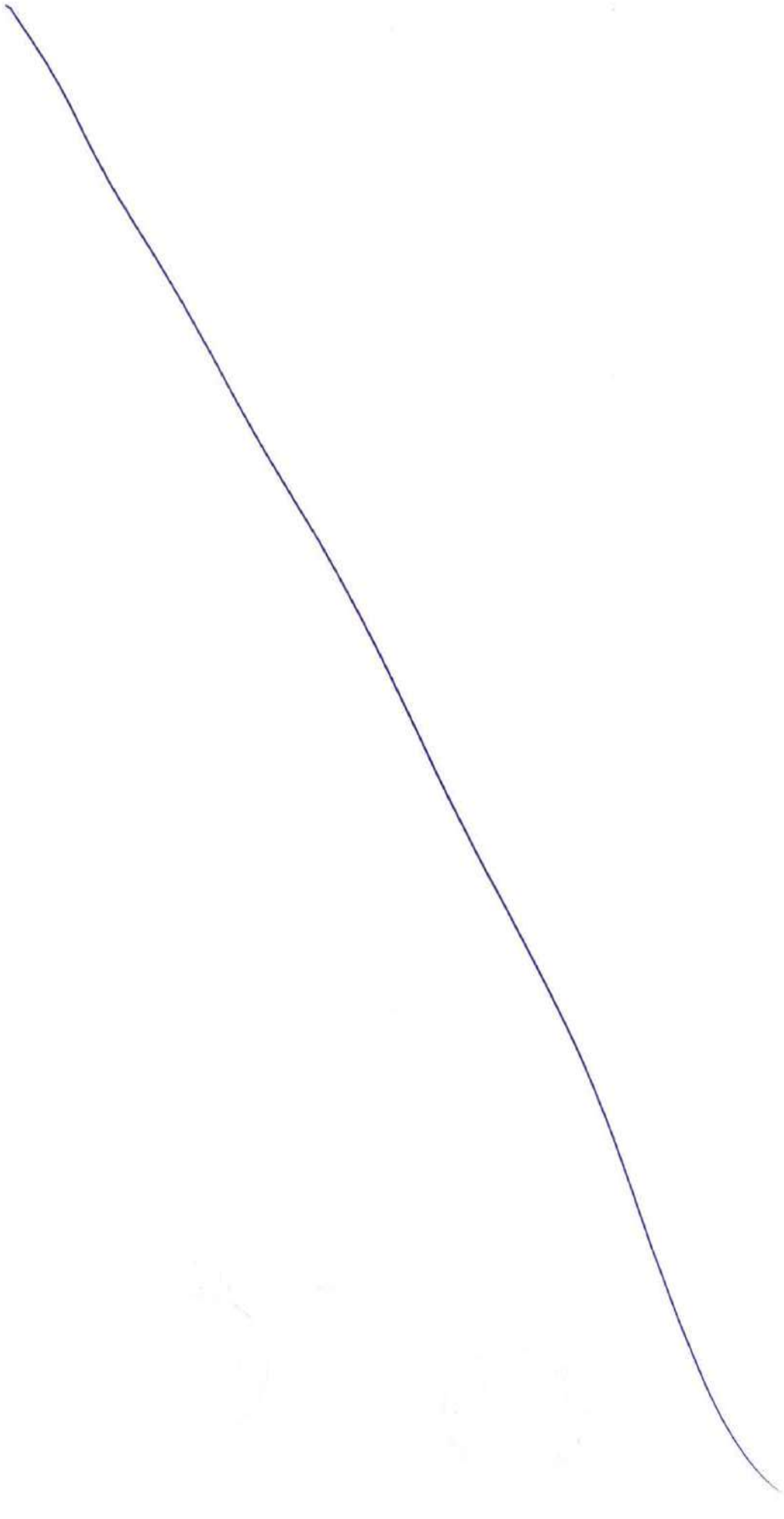
Transverse steel is provided by diaphragms so that the deck plate is supported at typically 2.0 m intervals and webs and bottom flanges are supported at typically 4.0 m



intervals. The reason for the short interval of the support of the deck plate is due to the fatigue requirements according to Guidelines for Fatigue Design of Steel Highway Bridges,2002 (Japan Road Association).

Diaphragm types T (truss) and P (plate) provide support for both deck plate, webs, and bottom flange. Diaphragm type T is applied when the girder depth exceeds 3.3 m, since the weight of the truss diaphragm is less than for a plate diaphragm. Diaphragm type P is used only when the girder depth is 3.3 m. For this depth the girder depth is small enough to allow all assembly blocks to have the full depth of the section, i.e. no horizontal transverse joint is needed. Diaphragm type I (intermediate) only provides support for the deck plate and are located in between two type T or P diaphragms. Diaphragm type B (bearing) is applied at the pier locations where the bridges are supported by bearings.

A typical 12 m erection segment including diaphragm types is shown in elevation in Figure 4-4. The site erection splice location is chosen at a location where demands due to local loads on the deck plate are small to minimized the demand on the deck plate trough connections.



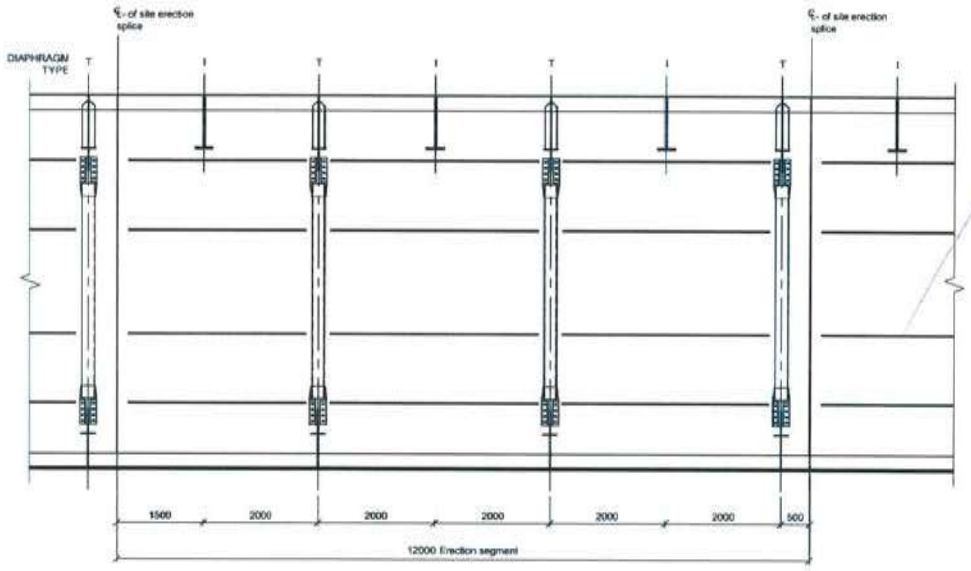
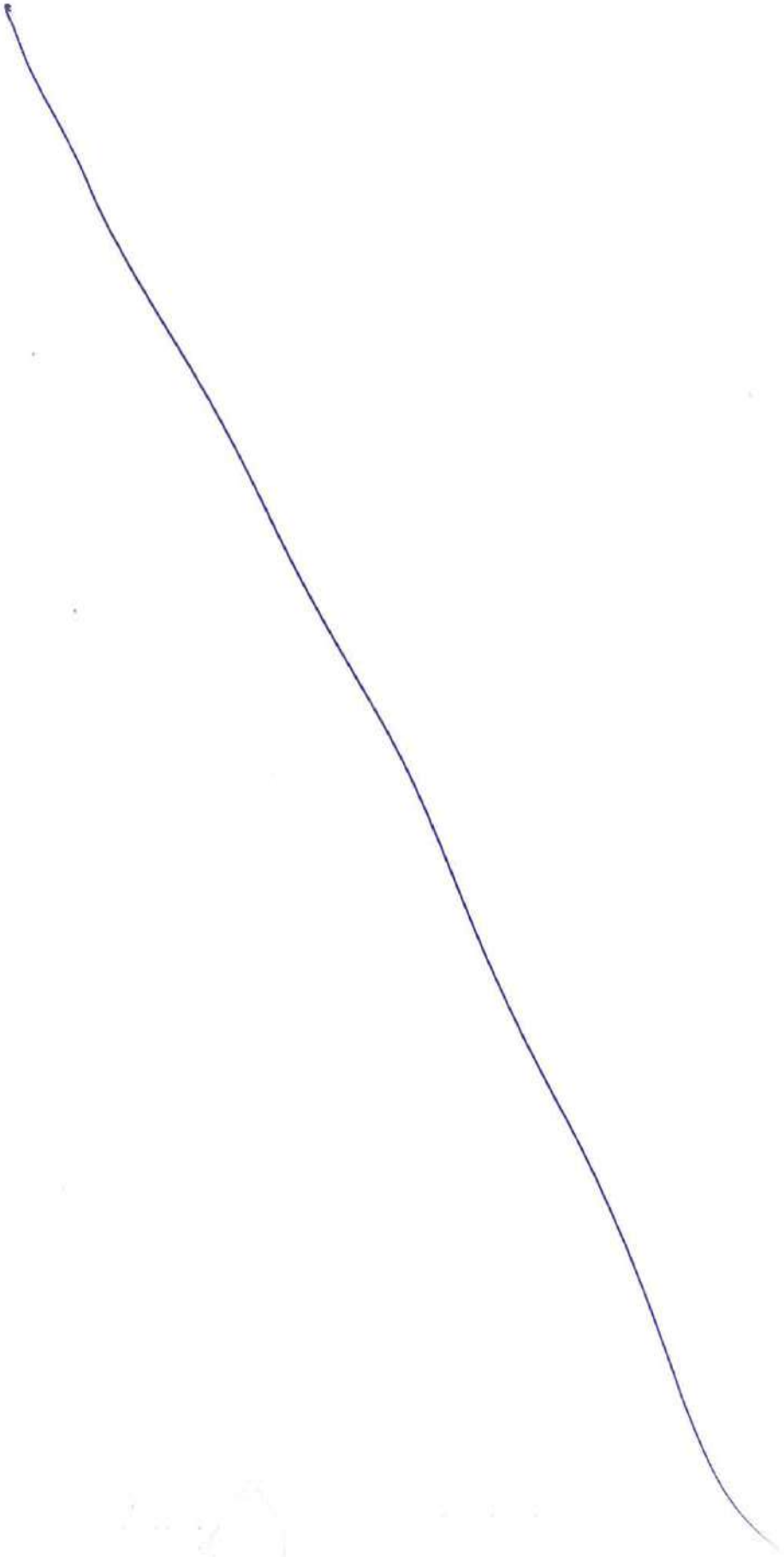


Figure 4-4 Elevation of typical 12 m erection segment

The bridges girders are assembled in fabrication segments of typical 12 m length. Each fabrication segment consists of assembly panels that are connected by longitudinal bolted connections for webs, bottom flanges and diaphragms and with welded connections for the deck plate.

The fabrication segments are connected by transverse bolted connections for webs and bottom flanges and with welded connections for the deck plate. The fabrication segments are assembled to large erection segments with consideration to a pre-camber to ensure the correct shape of the final bridge.

All bolted connections are high strength friction grip connections. Provision shall be made for a future installation of a dehumidification system and in case this will be installed, the bolted connections shall be applied with suitable sealant to make the girders air tight.



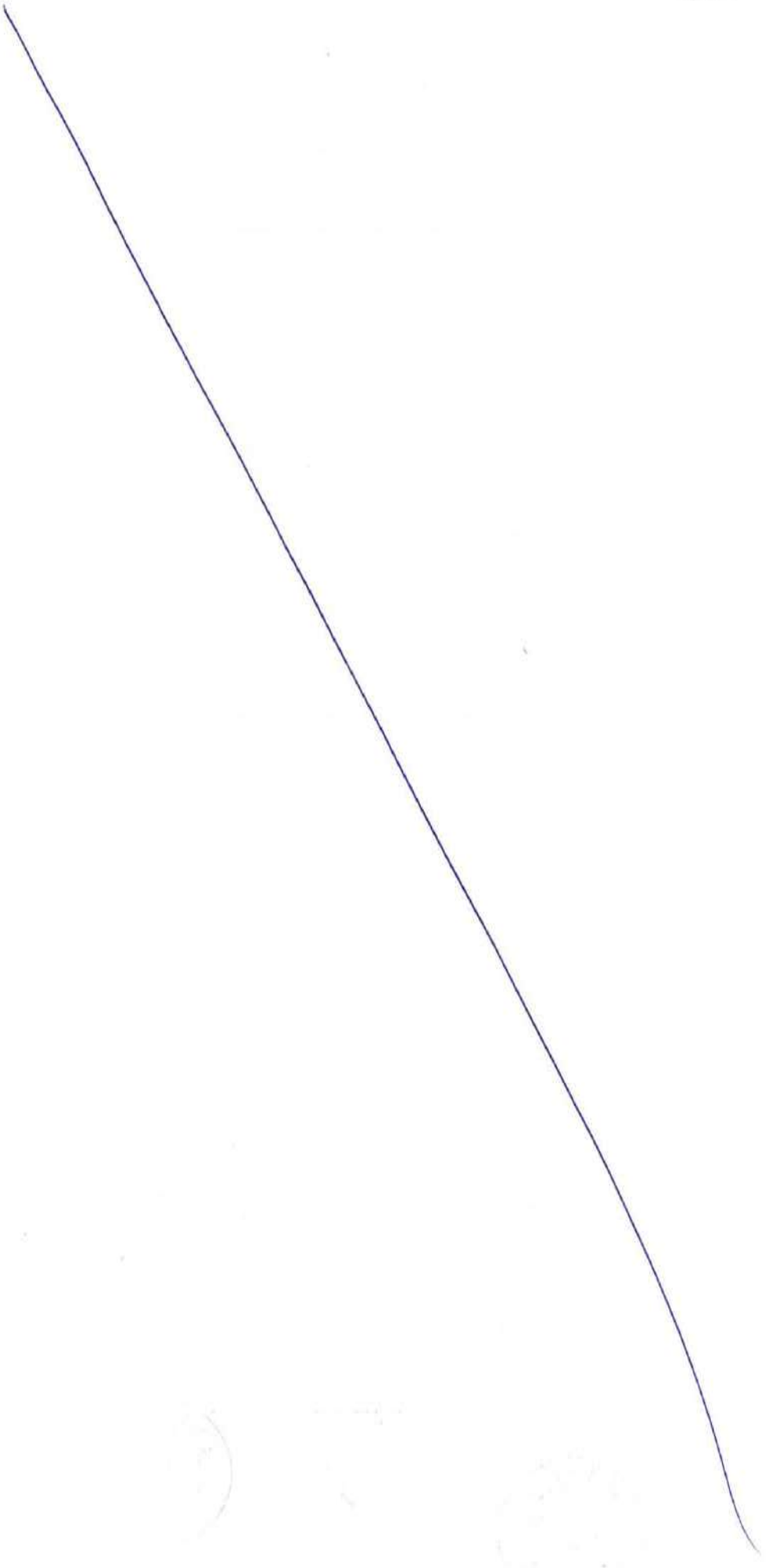
Note on Proposed Design Concept

The erection of the large erection segments is planned so that an optimum dead load bending moment distribution can be achieved. The optimum bending moment distribution will be achieved by applying vertical jacking at pier locations. The maximum amount of vertical jacking is 4.2 m. It is noted that the required length of vertical jacking is moderate due to the fact that the girders are very stiff in order to satisfy the deformation requirements.

Bridge P1-OS01 and part of P1-OS03 are erected by push launching whereas the other bridges are erected by large segment erection using strand jacks at pier segments. The later gives a high positive bending moment at the center of the spans, but due to the large girder depths at mid span, no strengthening is required due to the lifting situation using strand jacks.

The steel bridges are analysed based on loads and load combinations from IRC:6 using allowable stress design and the structural verification is based on Specifications for Highway Bridges Part II, Steel Bridges (2002) by JRA (Japan Road Association). Due to large gravity loads due to dead load and traffic loads load combination I according to IRC:6 is found to be governing over load combinations considering wind, temperature or seismic actions. The total global gravity loads are formed by comparable contributions from girder self-weight, superimposed dead loads and traffic loads. The girder self-weight is highly depending on the girder depth and plate thicknesses due to the structural demands and it varies between approximately 75 kN/m and 105 kN/m. The superimposed dead load is almost constant and makes up approximately 75 kN/m, which is mainly due to the surfacing and the concrete barriers. Traffic live load including impact factor, congestion factor and reduction factor makes up approximately 90 kN/m.

The steel material is chosen so that SM570 is generally used for main longitudinal steel whereas SM490Y is used for transverse steel.



The structural analysis of the bridges is made using a global FE model for all bridges supplemented by local FE models for local loads.

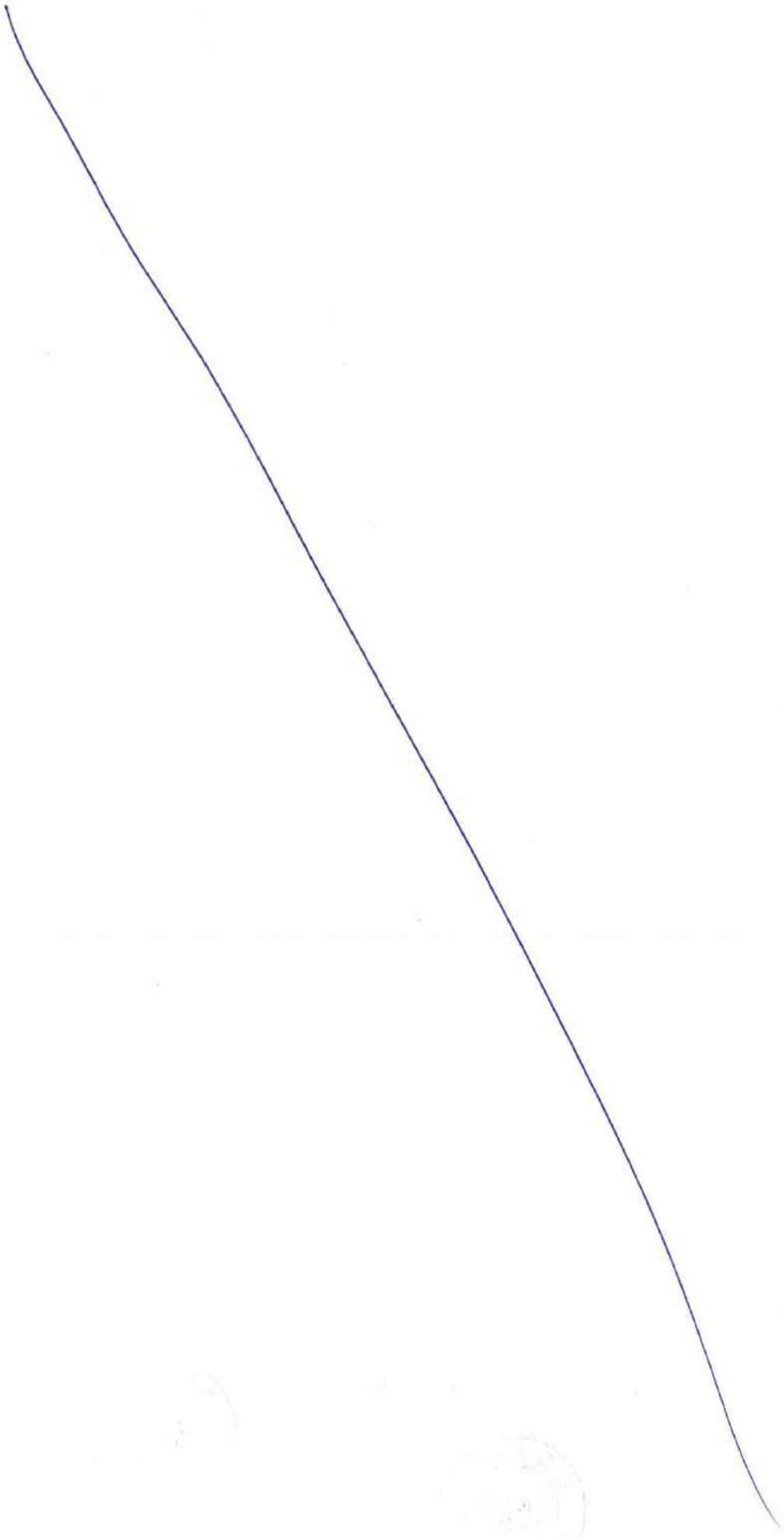
4.1.2 Design difficulties/challenges

The steel bridges are analysed based on loads and load combinations from IRC:6 using allowable stress design and the structural verification is based on Specifications for Highway Bridges Part II, Steel Bridges (2002) by JRA (Japan Road Association) [JRA 2002]. This mix of codes requires that the designer make a number of interpretations on how these codes should be combined. In JRA 2002 there are a number of verification requirements that refer directly to vehicles defined in JRA codes and do not exist in IRC:6. Furthermore for the deflection check according to JRA 2002 it is not specified what load situation and load combination according to IRC:6 that applies.

4.1.3 Comments on the Employer's Requirements

The employers requirements does not specify the deflection criteria for the steel bridges and the deflection requirement is therefore based on a mix of IRC:6 for the loading and load combination whereas the deformation requirement of L/500 according to JRA 2002 is applied. This results in a strict deformation criteria that requires deep girders throughout the spans. When designing steel bridges according to other codes (such as American code AASHTO LRFD) the deflection criteria is optional and owner can often define the deflection criteria. Even if the suggested deflection criteria according to AASHTO LRFD is used this is less onerous than the one according to JRA 2002 combined with IRC:6.

The employers requirements does not clearly specify of steel barriers can be applied on the steel bridges or not. Since the concrete barriers make up almost half of the



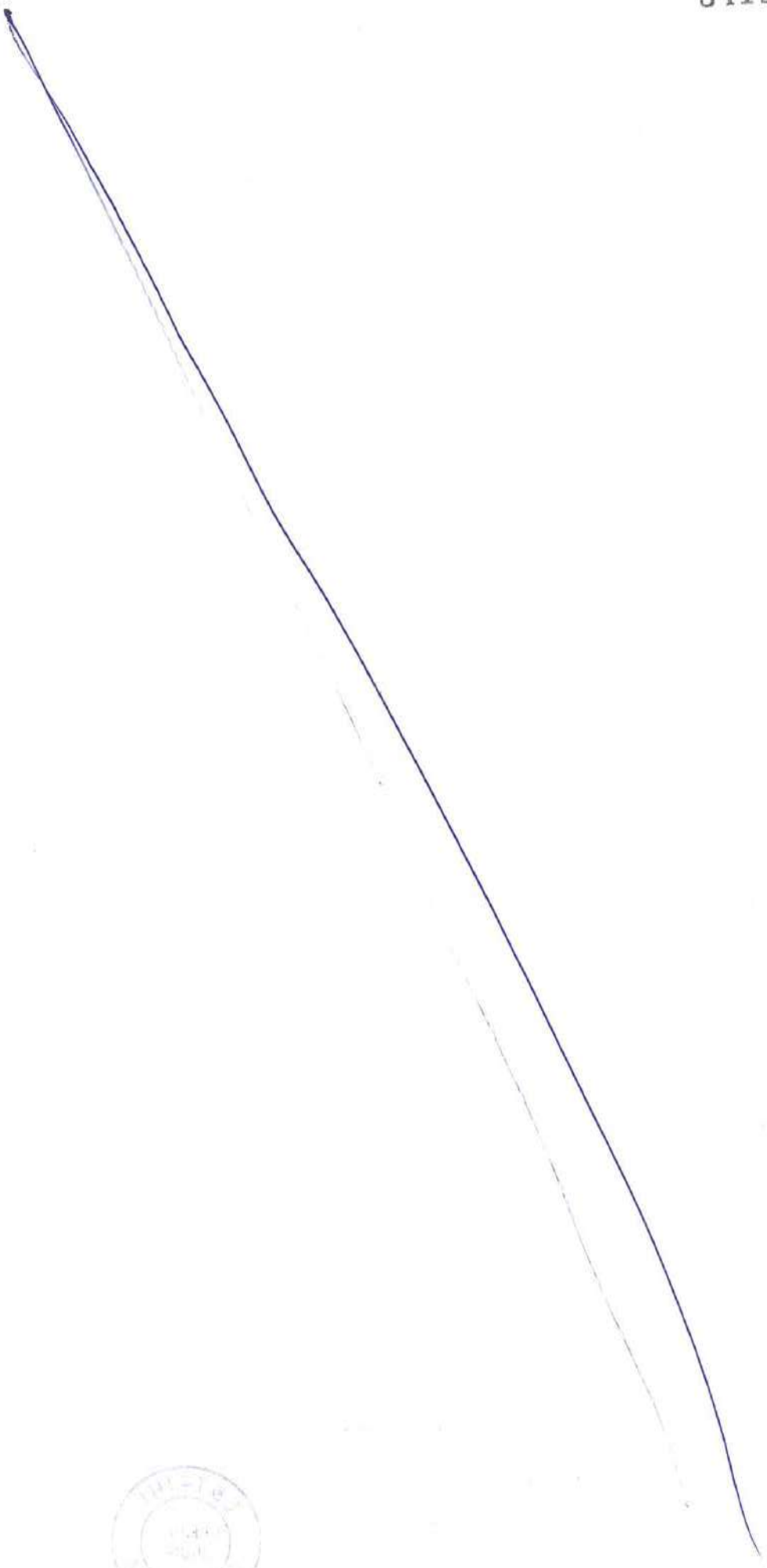
superimposed dead loads, it would be possible to reduce the steel quantities in case steel barriers could be applied instead.

4.2 Substructure

4.2.1 Design concept

Foundations:

For the steel bridges the foundations for the navigation spans consists typically of a common pile foundation for both carriageways as shown in Figure 4-5 below. Ten 2.2m diameter piles are used. The piles are provided with protection rings to safeguard against direct hit by a barge. In this way the impact force is transferred to the pile cap and which means that the impact load will be resisted by the entire pile group having sufficient capacity well above the assessed impact force.



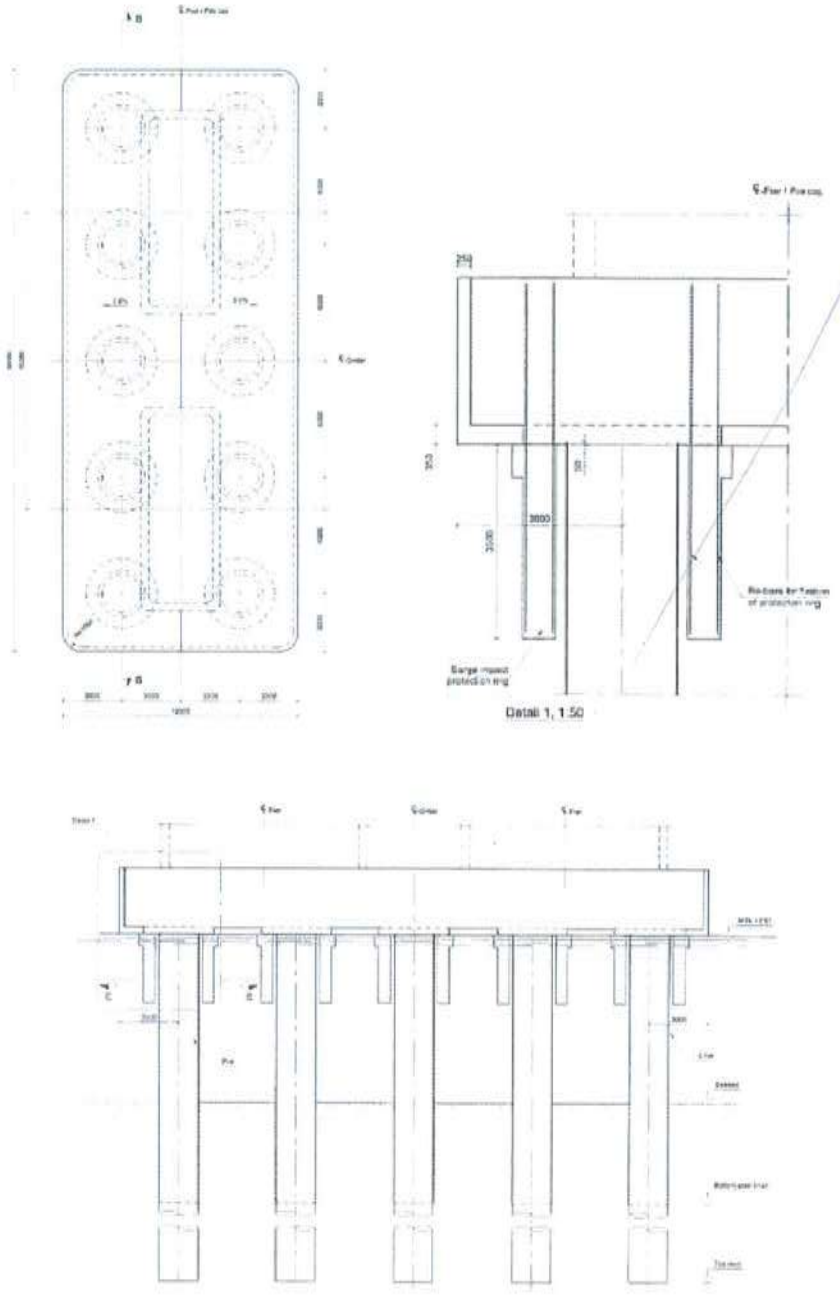
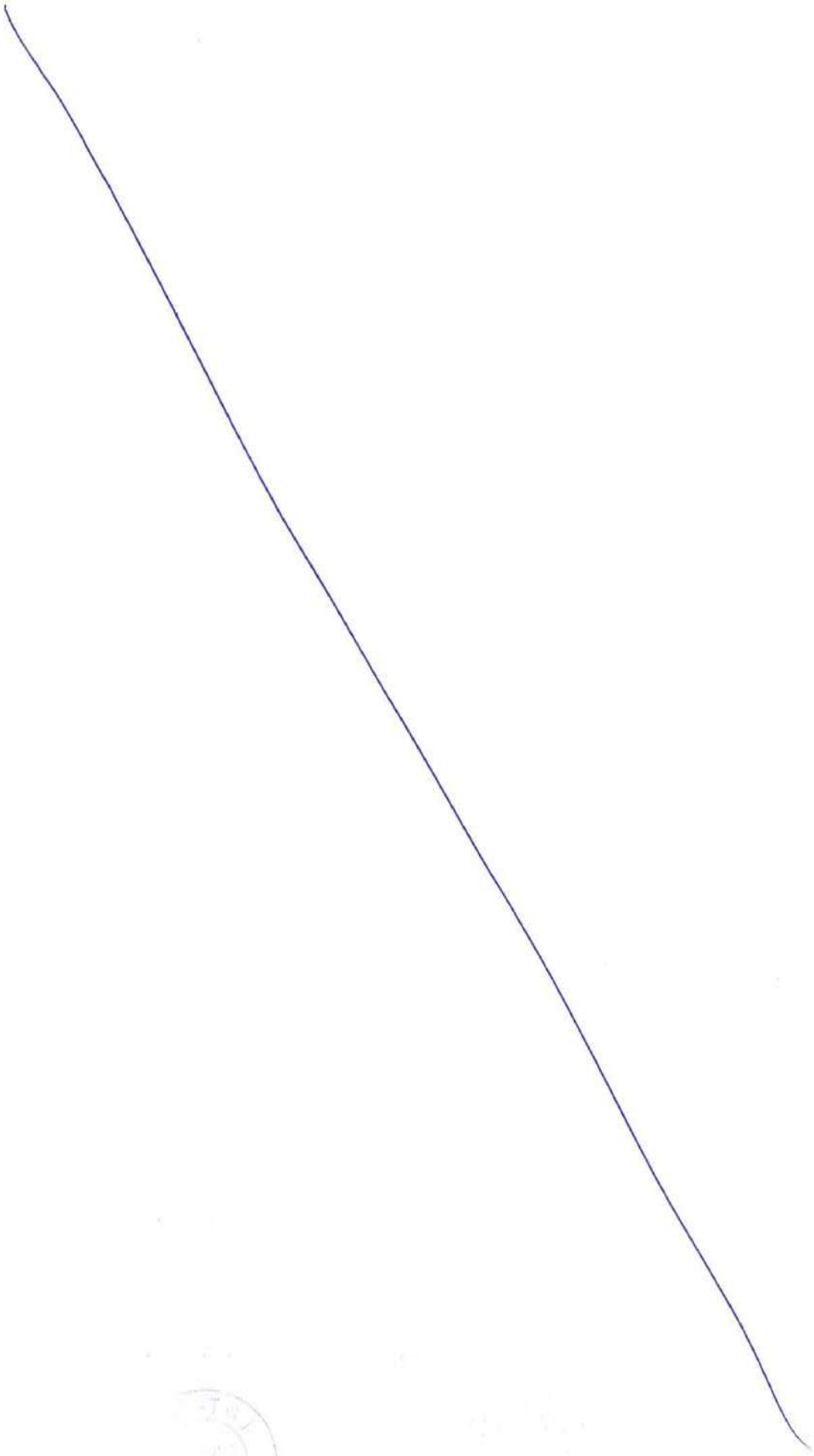


Figure 4-5 Steel bridges at navigation spans – pile foundations



Note on Proposed Design Concept

The construction of the foundations is in principle similar to foundations for the marine viaducts. Due to the much larger size of the foundations it is more relevant to split the construction of the PC-house into more sections.

Piers:

The pier shafts have rectangular cross section with rounded corners as shown on Figure 4-6 below. The pier head is widened in the longitudinal direction of the bridge to provide space for temporary support of the girders during construction.

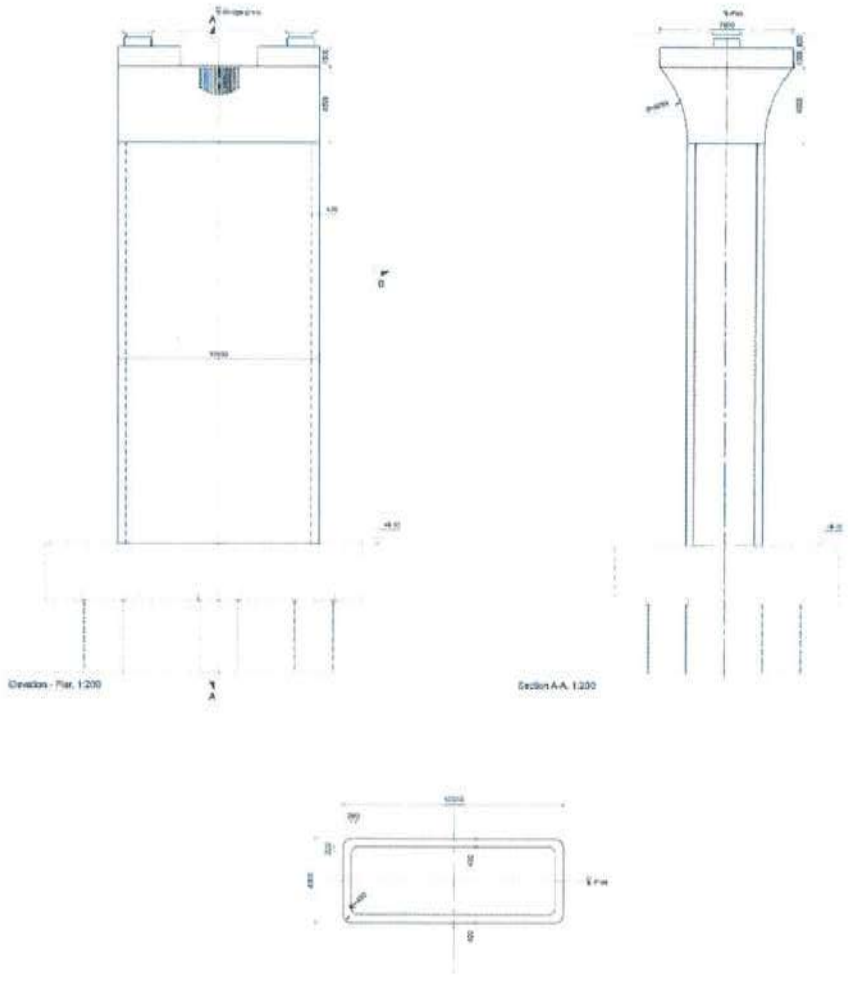
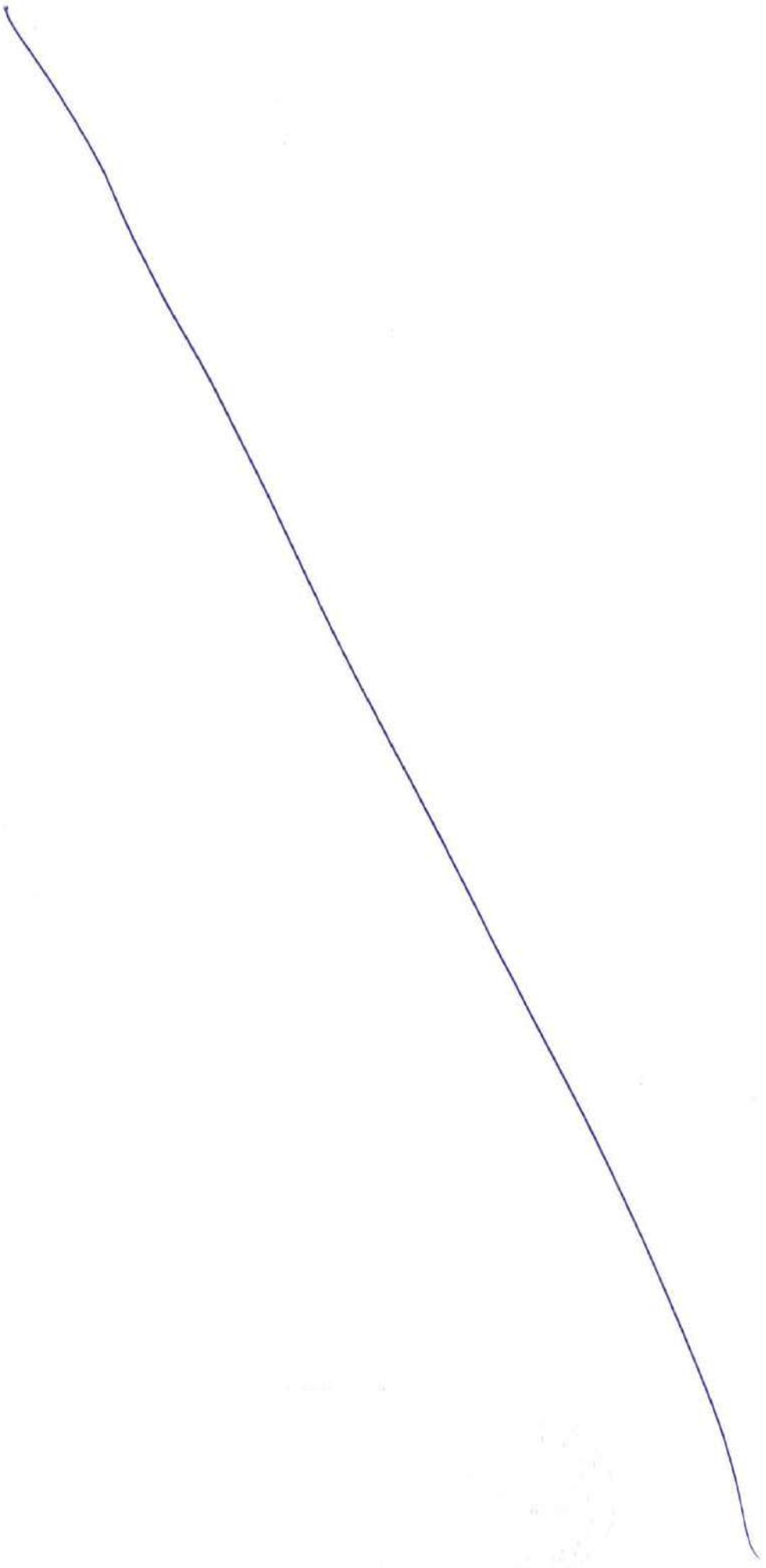


Figure 4-6 Steel bridges at navigation spans – piers



4.2.2 Design difficulties/challenges

The design challenges for the foundations are seismic loads and ship impact similar to the marine viaducts.

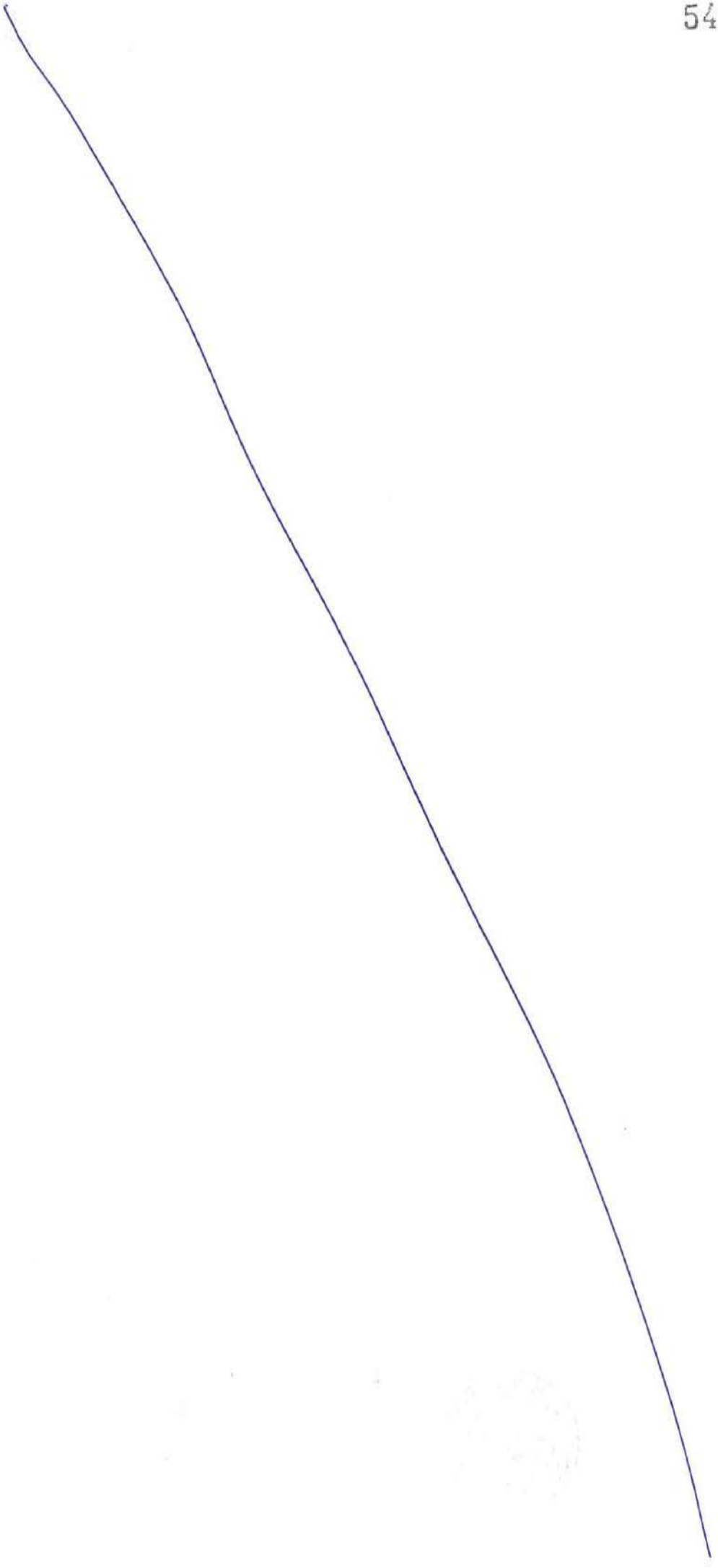
In the tender design the solutions to reduce the seismic response on the foundations are introduction of 2-3 fixed piers per expansion section to share the seismic response more equally on the foundations and providing slender piers in the longitudinal direction of the bridge.

For vessel impact it is proposed to protect the individual piles against a direct hit from a barge by providing special protection rings around the piles being able to transfer the impact force into the pile cap without any damage to the pile. The global capacity of the pile foundation is substantially enhanced by using a common foundation for both carriageways.

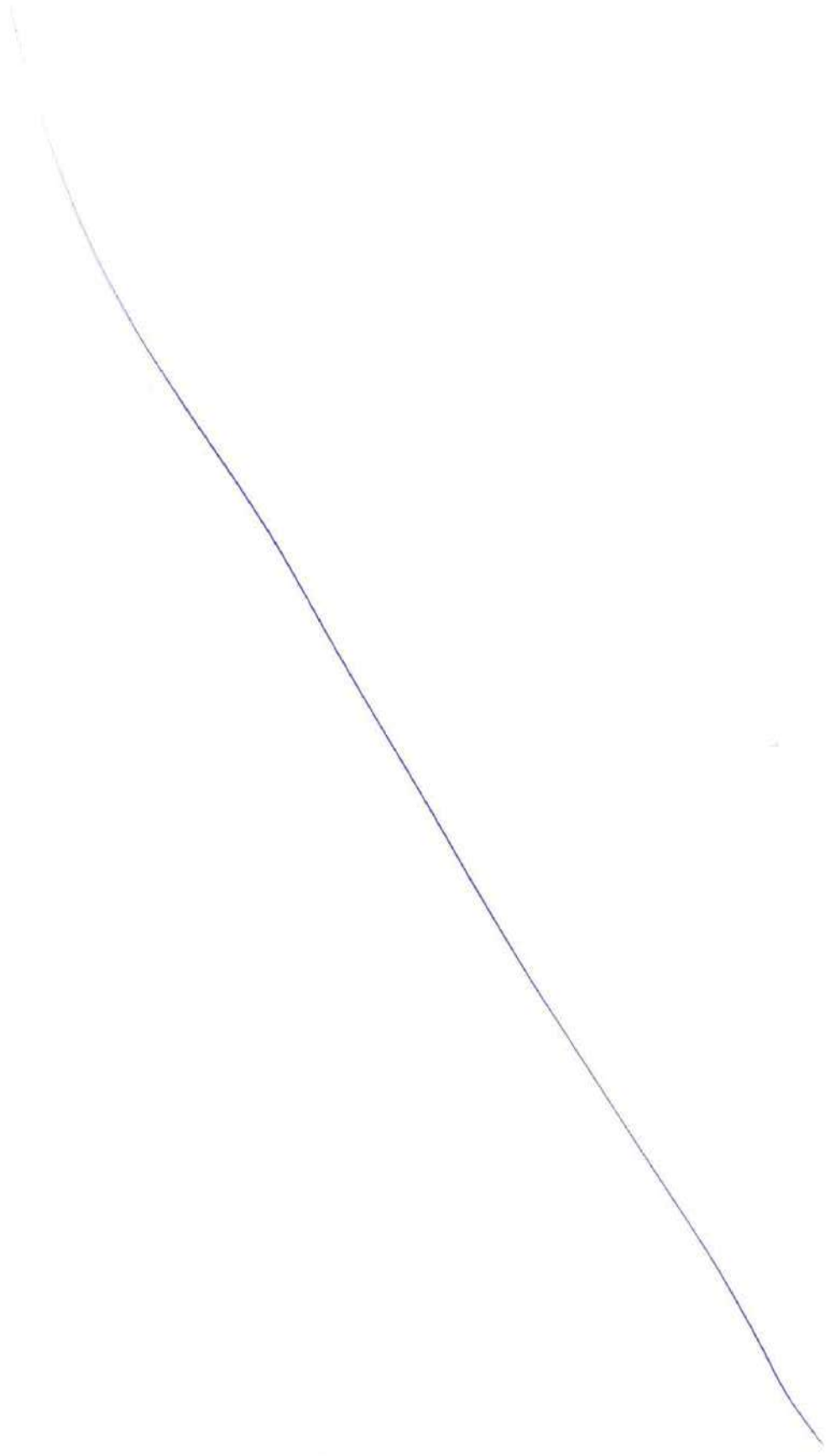
4.2.3 Comments to the Employer's requirements

In the Employer's requirements a design vessel for impact against the foundations adjacent to the navigation channels has been specified. Therefore, definition of the design vessel based on probabilistic method in AASHTO guidelines is not relevant.

The design of the protection system is assumed to be able to resist the total impact force from the design vessel.

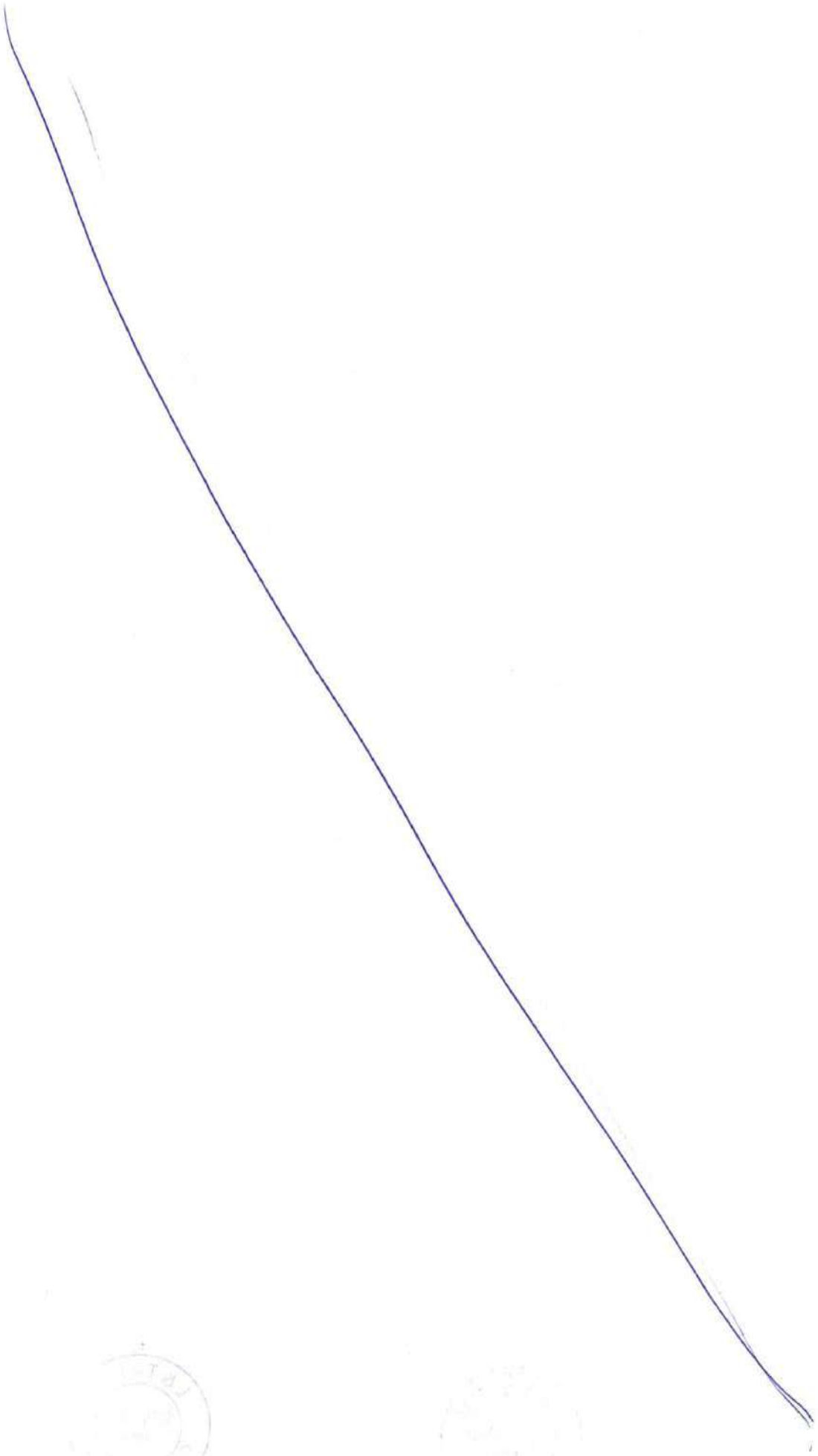


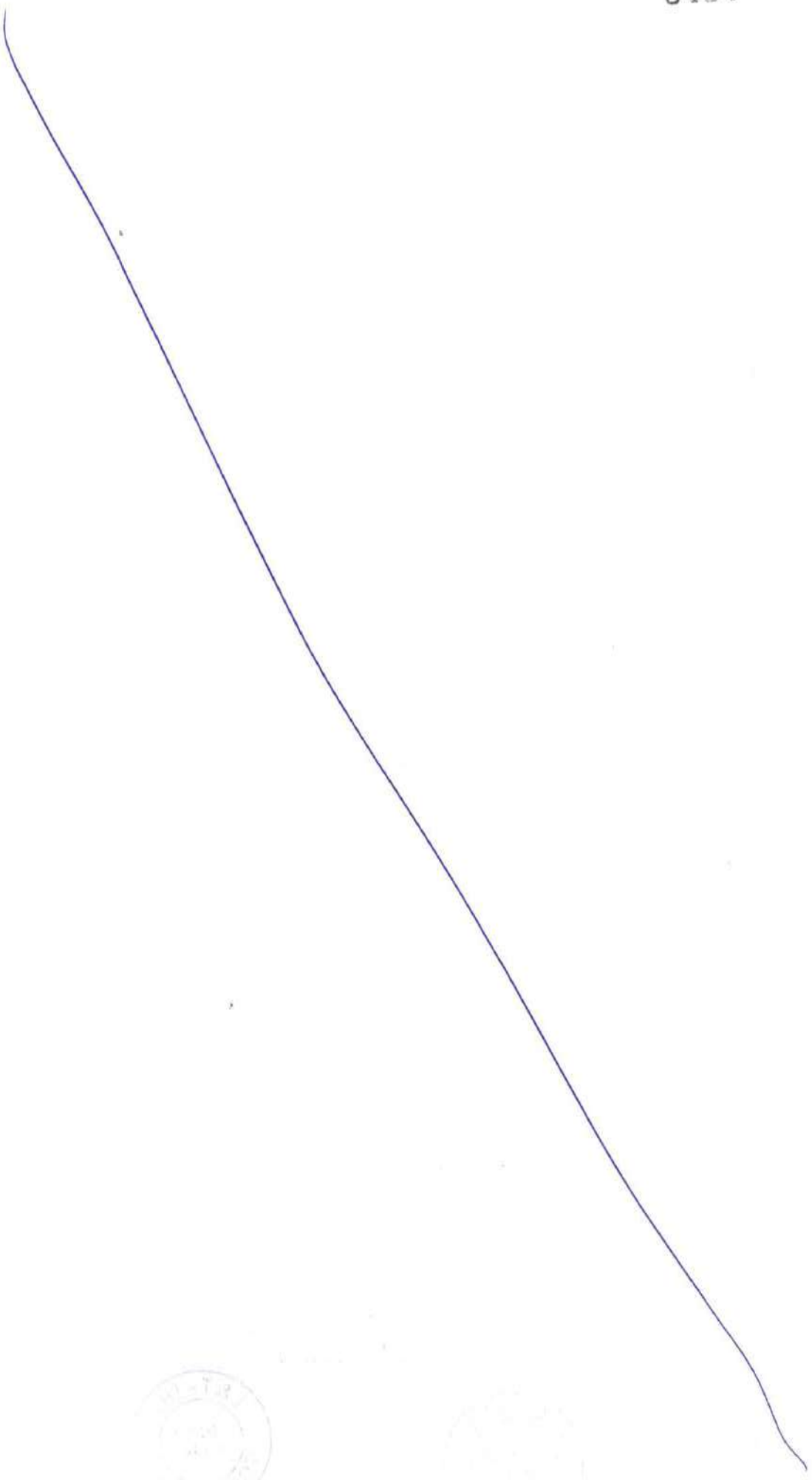
Design Basis Report

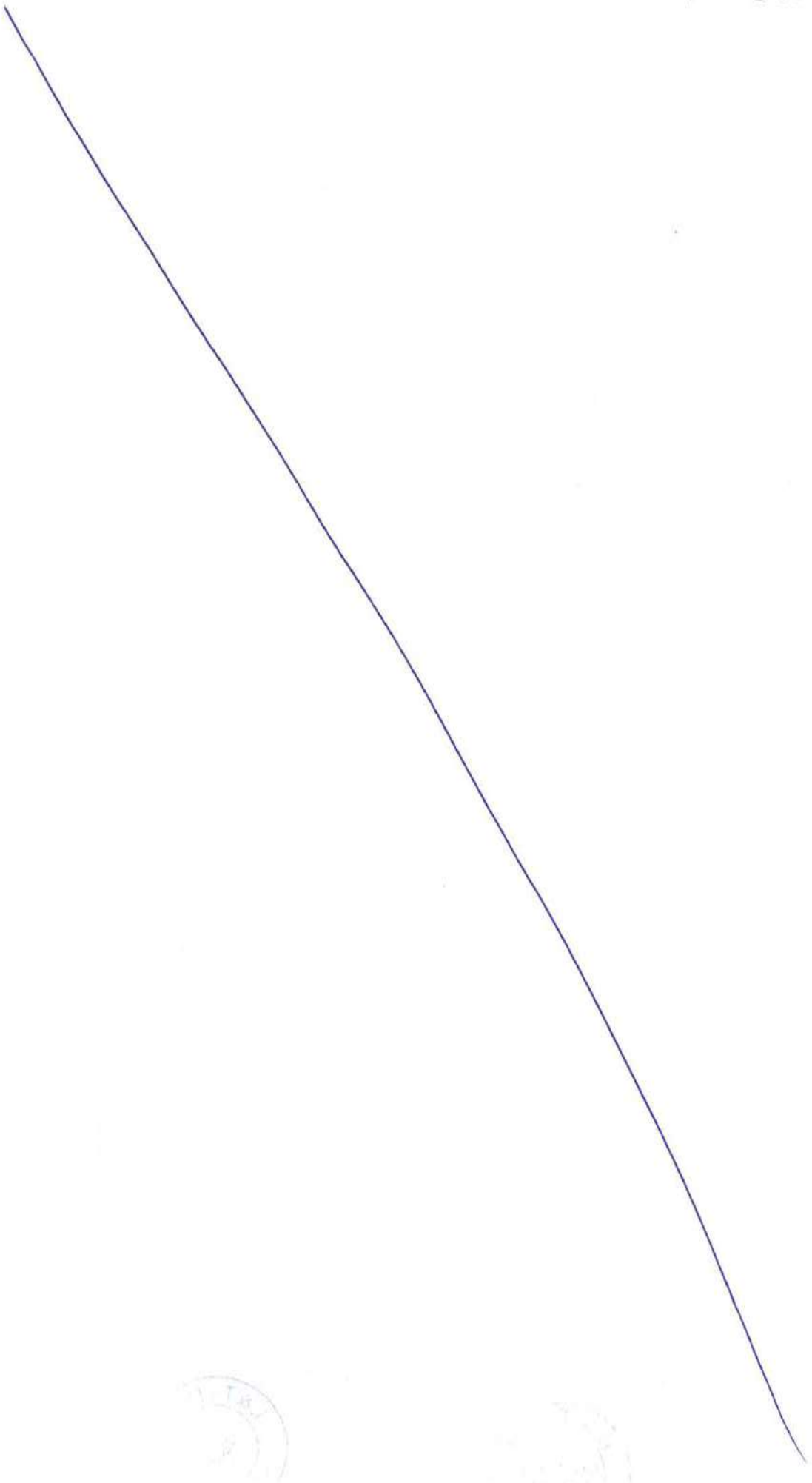


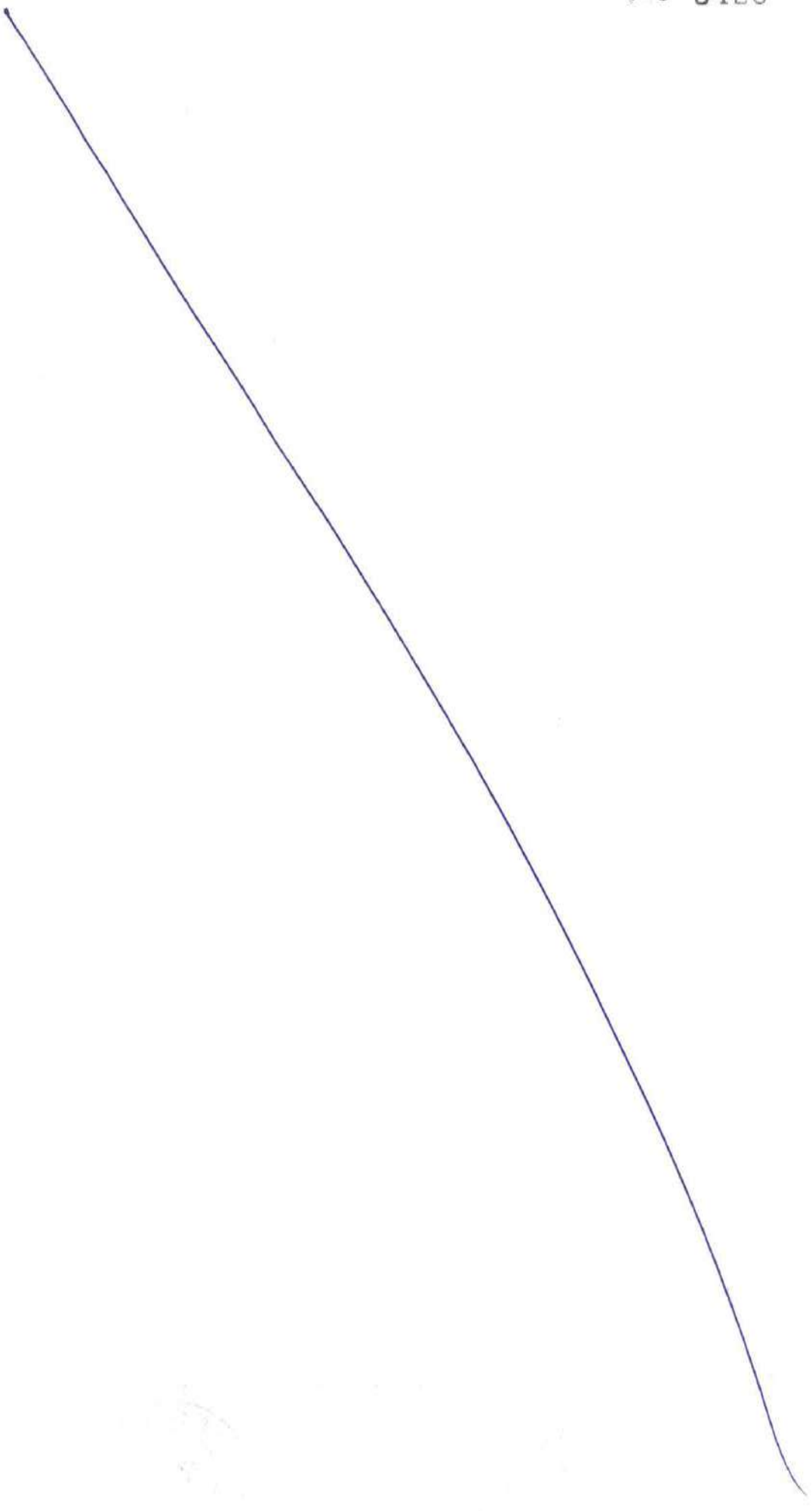
Design Basis Report

CONTENT









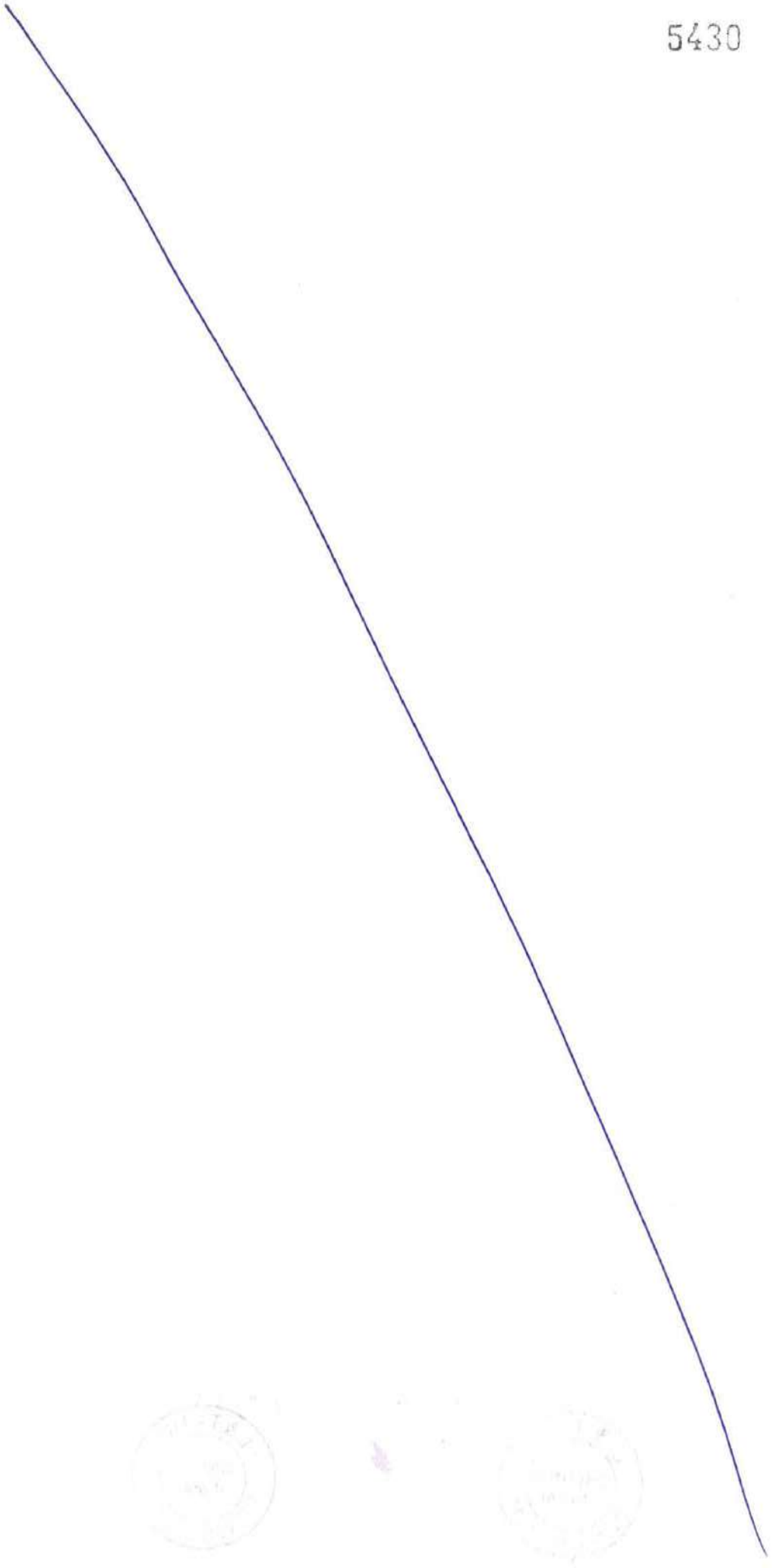
1 INTRODUCTION

1.1 SCOPE

This document constitutes the Design Basis for the Tender Design of the bridges for Package 1 of the Mumbai Trans Harbour Link, as follows:

› Road bridge above land, intertidal zone and sea:

Structure Name	Chainage (km)	Length (m)
LPS Land Viaduct Sewri	0+000 - 0+495	495
Concrete Viaduct C1 Intertidal	0+495 - 3+395	2900
P1-OS01 NS/SS Tata Thermal Power Station Intake & Discharge Channels	3+395 - 3+715	320
Concrete Viaduct C2 Marine	3+715 - 4+625	910
P1-OS02 NS/SS Tata Thermal Power Station Coal Berth Channel	4+625 - 5+308	683
P1-OS03 NS/SS Tata BPCL Power Cables, Submarine Pipe & Pir-Pau Jetty	5+308 - 6+078	770
Concrete Viaduct C3 Marine	6+078 - 8+620	2542
P1-OS04 NS/SS Thane Creek Channel	8+620 - 9+180	560
Concrete Viaduct C4 Marine	9+180 - 10+380	1200



› Sewri Interchange ramps and retaining walls:

Structure Name	Local Chainage (km)	Length (m)
Ramp A	-0+197.200 - 1+500.800	1698
Ramp B	0+005.010 - 1+535.010	1535
Ramp C1	0+265.680 - 1+205.680	940
Ramp C2	0+005.000 - 0+505.000	500
Ramp E	-0+140.146 - 0+767.854	908
Ramp F	0+250.400 - 0+630.400	380
Retaining Walls C2	0+505.000 - 0+645.000	150
Retaining Walls F	0+000.400 – 0+250.400	250

› Foundations and pier No.148 (Ch. 10+380 km).

1.2 MTHL PROJECT

Mumbai Metropolitan Region Development Authority (MMRDA) proposes to construct the Mumbai Trans Harbour Link (MTHL) across Mumbai Bay, between Sewri on the Mumbai side and Chirle on the Navi Mumbai side in Maharashtra State, India, as shown in Figure 1-1.

The MTHL will comprise a 21.8 km long 2 x 3-lane highway supported principally on bridges, with interchanges incorporating access ramps.

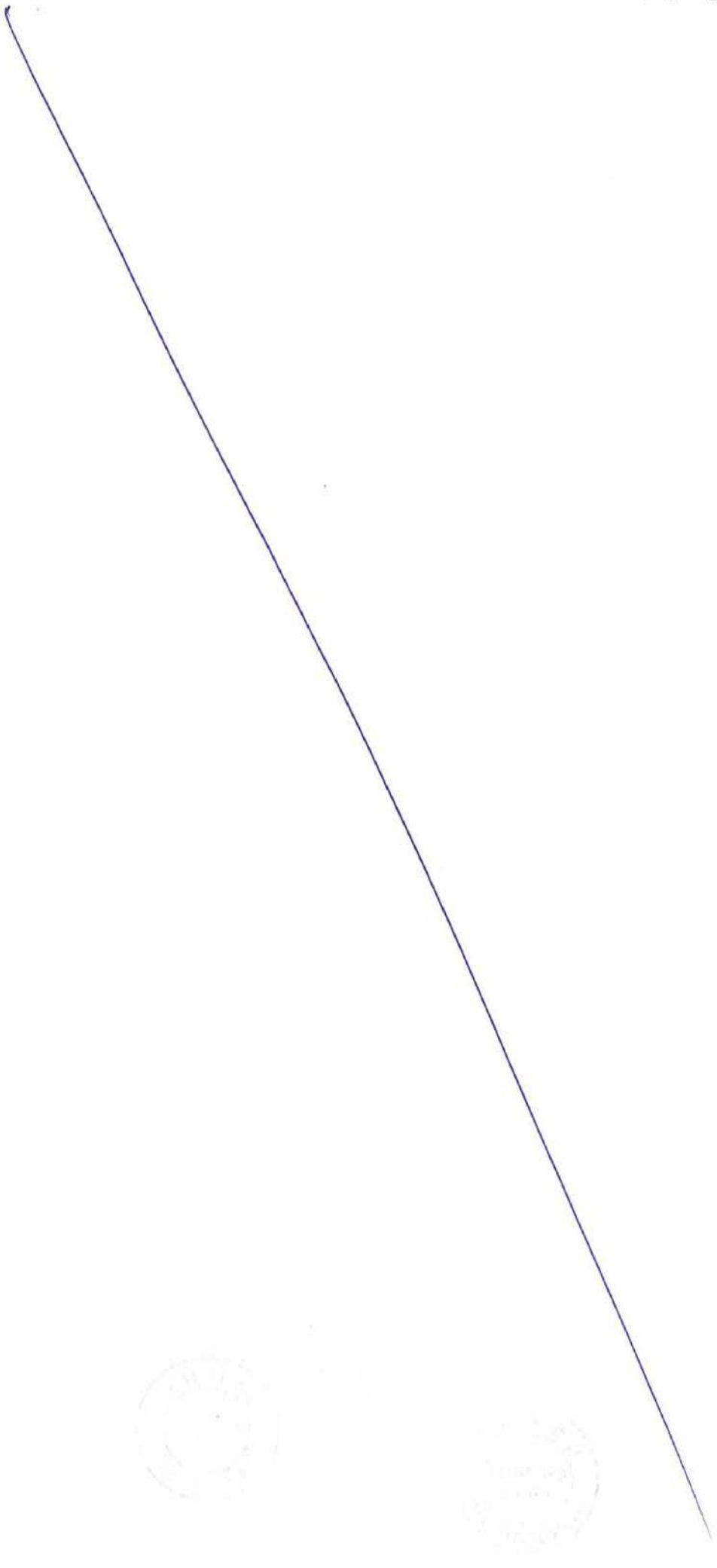
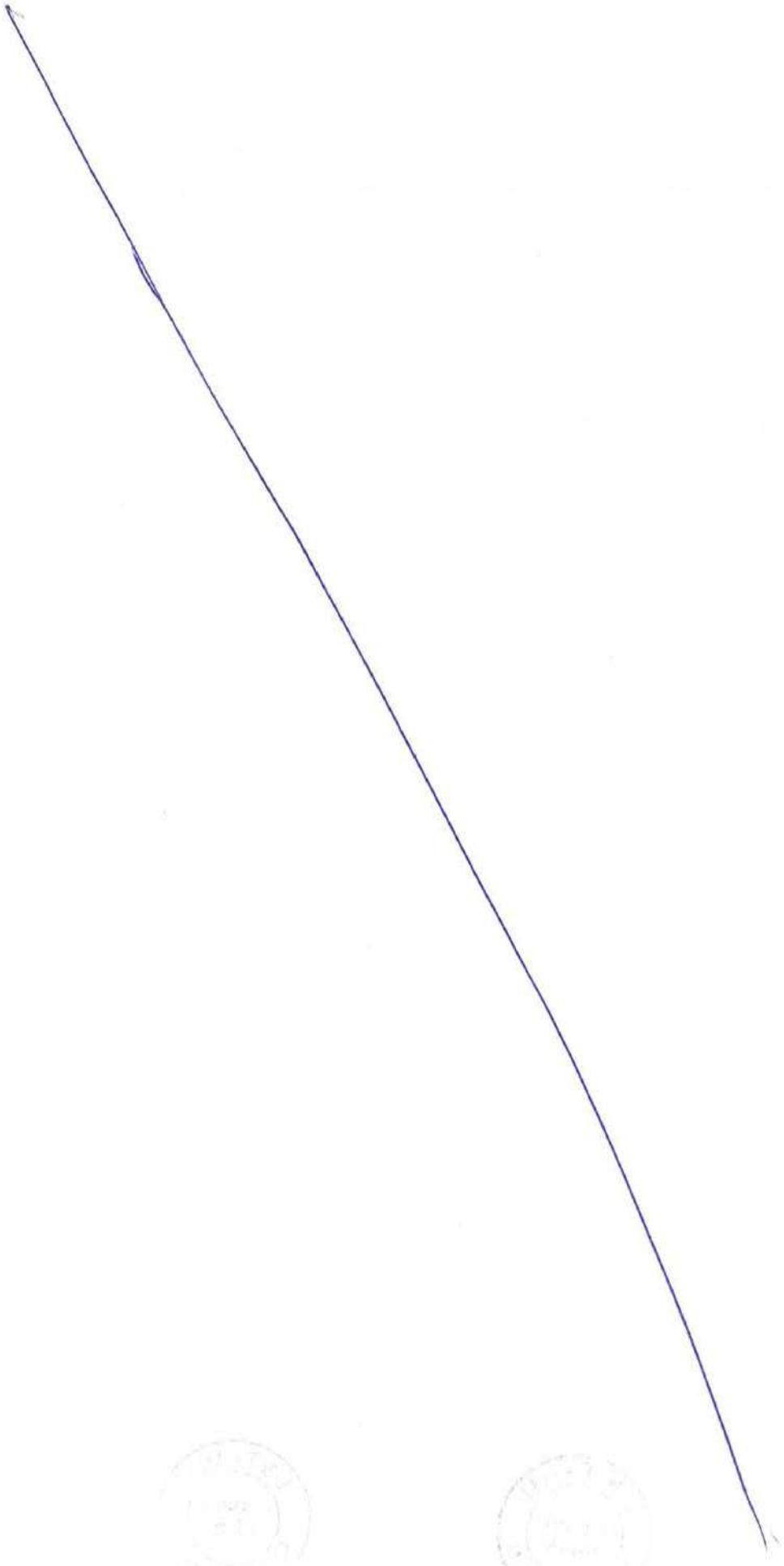


Figure 1-1 Mumbai Trans Harbour Link (MTHL) – Location plan

The land works, intertidal and marine zones for the main bridges are defined as follows:

- Land works: Ch. 0+000 km to Ch. 0+495 km
- Intertidal: Ch. 0+495 km to Ch. 3+395 km
- Marine: Ch. 3+395 km to Ch. 10+380 km



2 DEFINITIONS

2.1 BIDDING DOCUMENTS AND EMPLOYER'S REQUIREMENTS

Unless noted otherwise in this Design Basis, the Tender Design is based on the Employer's Requirements in the Bidding Document, with Addenda, as follows:

- Bidding Documents for Procurement of Mumbai Trans Harbour Link Project (Package-1). Construction of a 10.380 km long bridge section (Ch. 0+000 – Ch. 10+380) across the Mumbai Bay including Sewri Interchange. Volume II. Part 2 – Employer's Requirements. Section VI. Employer's Requirements.
- Addendum No.1 to Bidding Documents (22 May 2017)
- Addendum No. 2 to Bidding Documents (01 June 2017)
- Addendum No. 3 to Bidding Documents (21 June 2017)
- Addendum No. 4 to Bidding Documents (21 June 2017)
- Addendum No. 5 to Bidding Documents (07 July 2017)

2.2 DESIGN STANDARDS

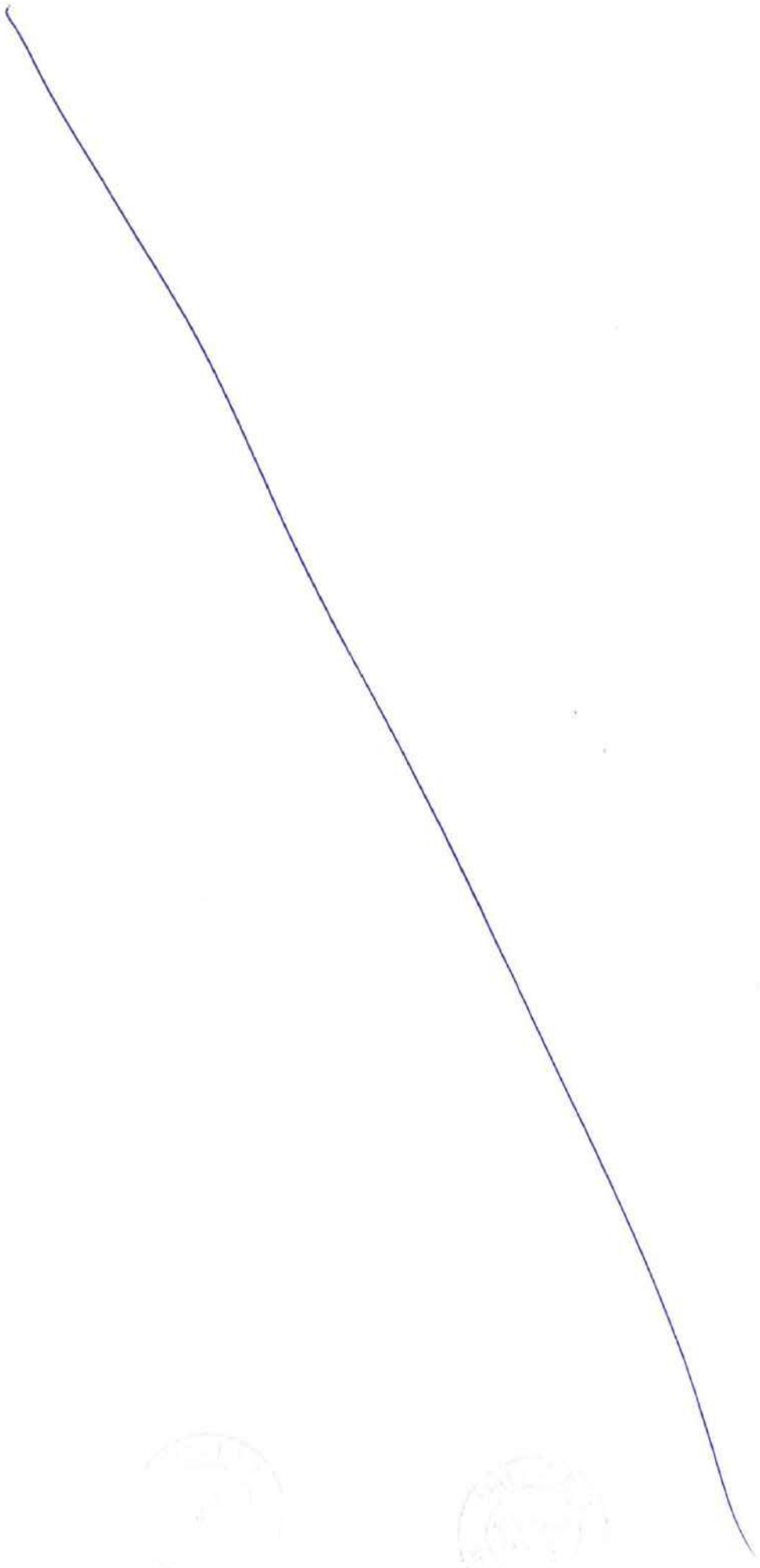
The design standards and codes to be used in the Tender Design are listed in AppendixA.

2.3 UNITS

The SI unit system shall apply.

2.4 PROJECT COORDINATE SYSTEM

The project grid coordinate system shall be WGS84/UTM43N (ref. Employer's Requirements, section 11.2 (ERG-25).



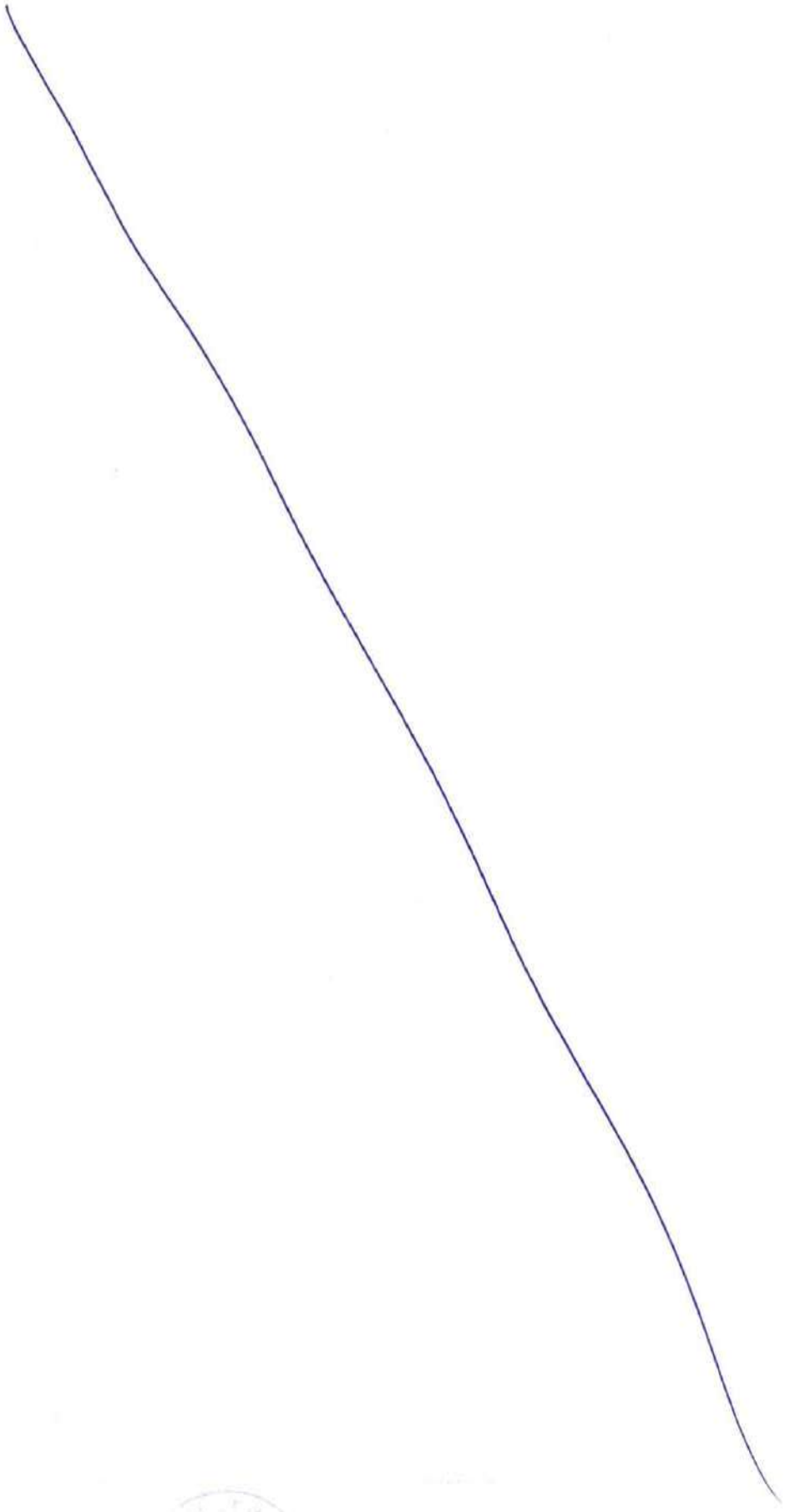
2.5 PROJECT DATUM

The datum for vertical control shall be Chart Datum (CD).

2.6 WATER LEVELS

Mean Sea Level (MSL) = +2.51 m CD

Highest High Tide Level (HHTL) = +5.80 m CD



3 FUNCTIONAL REQUIREMENTS

3.1 HIGHWAY TYPE

The MTHL main bridge shall carry a highway with dual three-lane carriageways.

The interchange ramps shall each carry two traffic lanes.

The land viaduct between Ch 0+000 km and Ch 0+495 km shall carry a dual two-lane carriageway.

3.2 DESIGN TRAFFIC SPEED

The design traffic speed for the main carriageway shall be 100 km/h.

The design traffic speed for the ramps shall be 40 km/h.

3.3 BRIDGE ALIGNMENT

The carriageway alignment shall be as shown in the Outline Specifications and Outline Drawings in the Bidding Documents (see §2.1, above).

Deviations from the horizontal alignment are not permitted. Minor changes to the vertical alignment are permitted, provided that alignment and vertical clearance requirements are fulfilled.

3.4 FUNCTIONAL DECK CROSS-SECTIONS

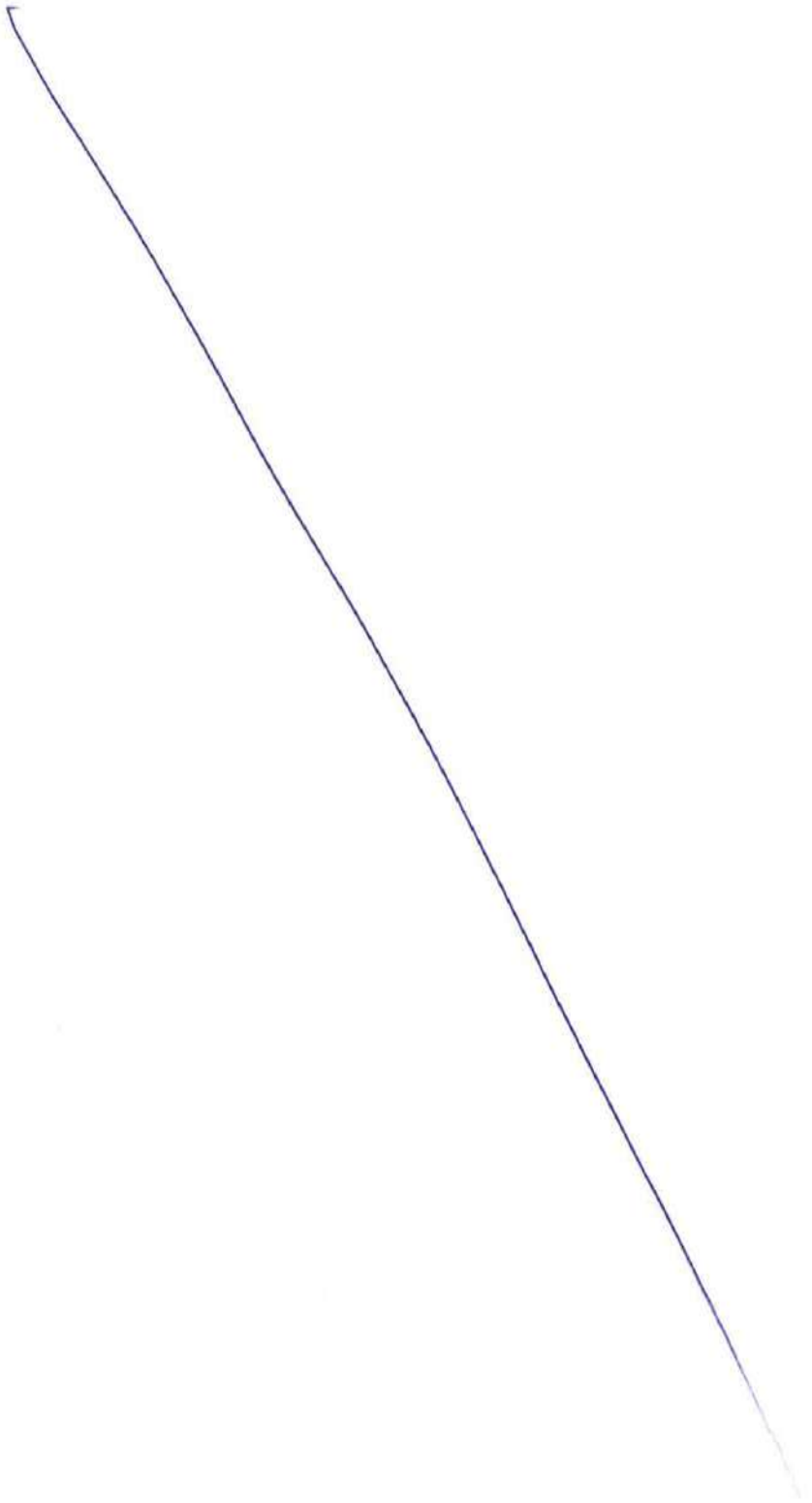
The functional cross section for the main carriageways from Ch 1+135 km to Ch 10+380 is shown in Figure 3-1.

The functional cross section for the ramps at the Sewri Interchange is shown in and from Ch 0+495 km to Ch 10+380 km is shown in Figure 3-2.

The functional cross section for the land viaduct from Ch 0+000 km to Ch 0+495 km is shown in Figure 3-3.

Between the end of the ramps at Ch 0+495 km and the start of the standard width section of the main carriageways at Ch 1+135 km, the overall width of the bridge deck tapers at the Sewri Interchange.

The width of the carriageways at Ch 0+500 km is show in Figure 3-4.



The width of the carriageways at Ch 0+600 km is show in Figure 3-5.

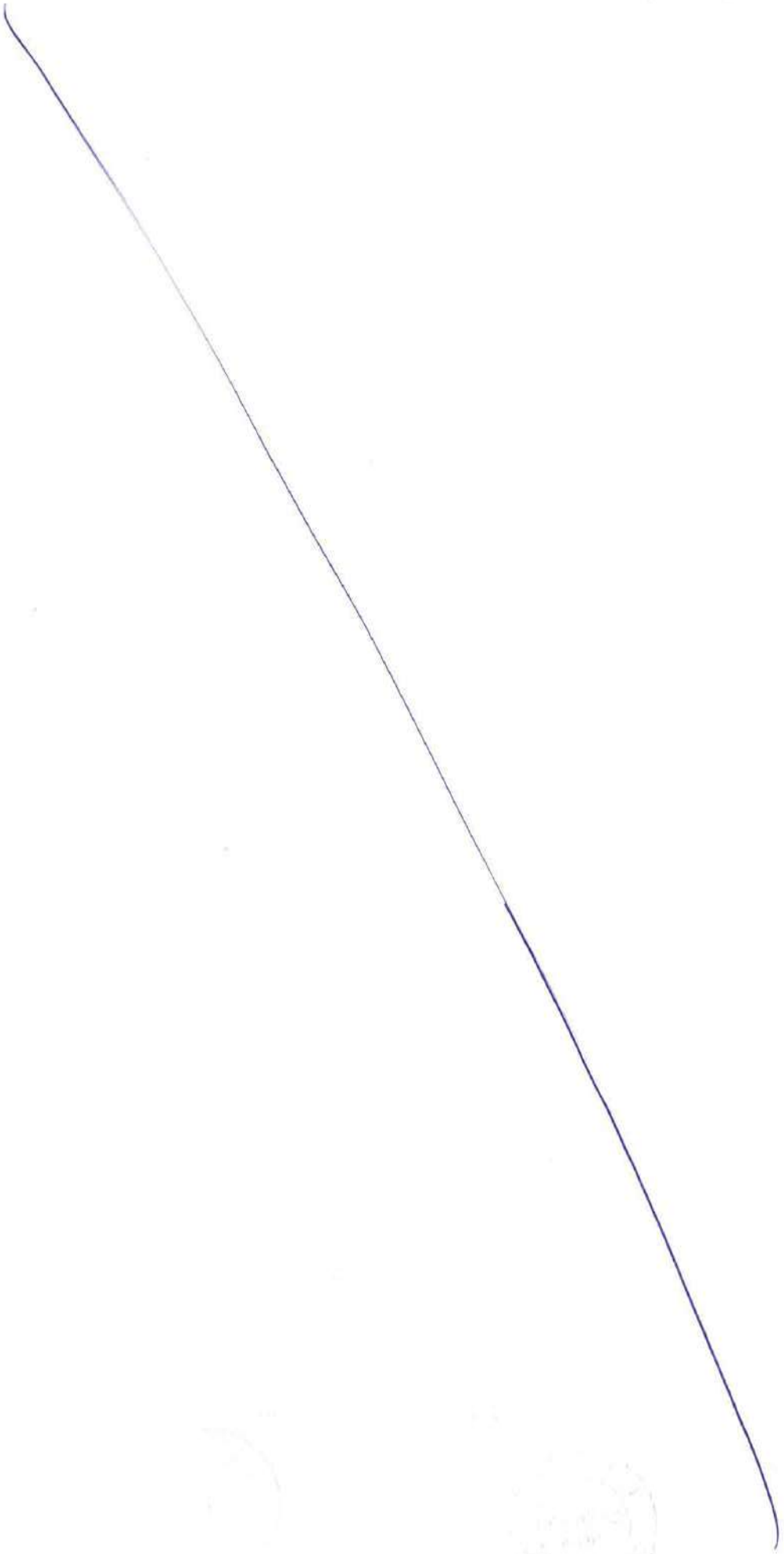
The width of the carriageways at Ch 0+750 km is show in Figure 3-6.

The width of the carriageways at Ch 0+850 km is show in Figure 3-7.

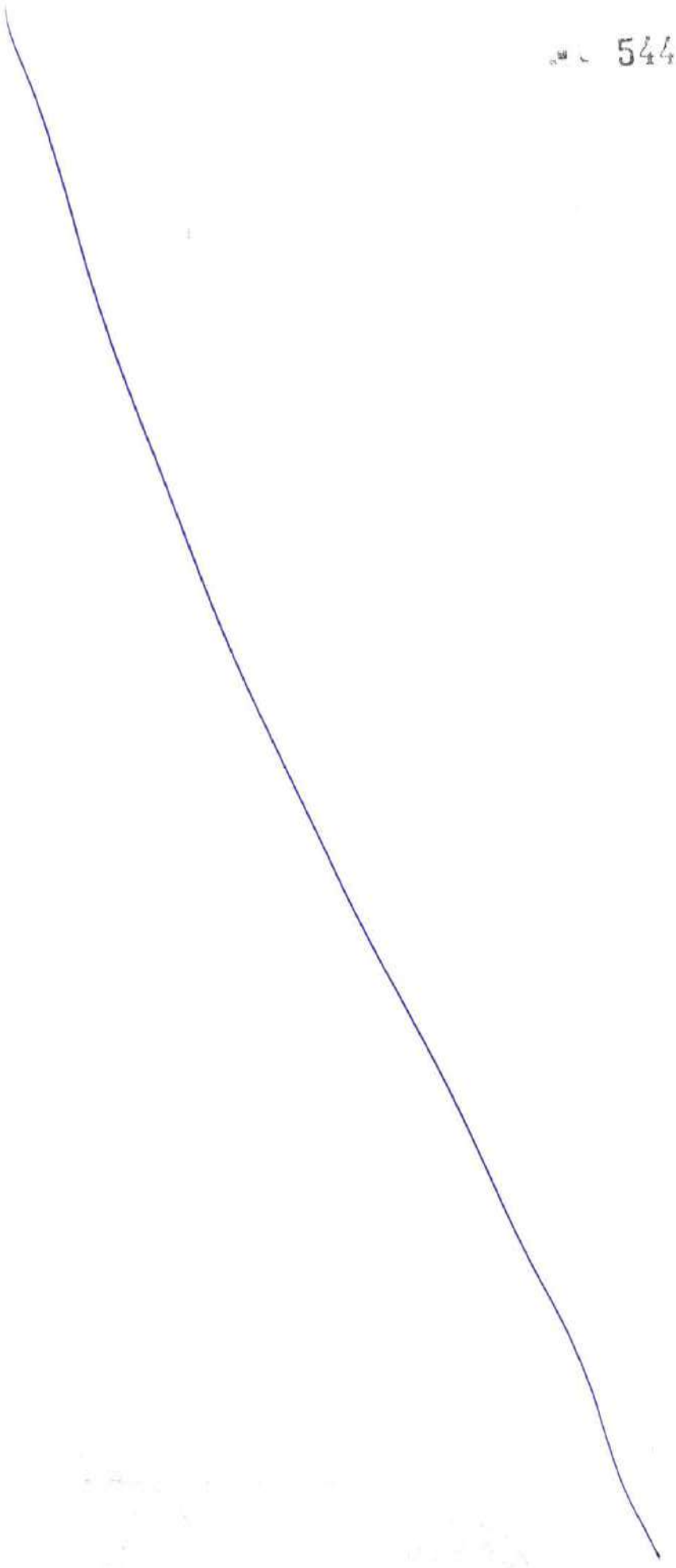
The width of the carriageways at Ch 0+950 km is show in Figure 3-8.

The width of the carriageways at Ch 1+050 km is show in Figure 3-9.

The width of the carriageways at Ch 1+100 km is show in Figure 3-10.



Design Basis Report



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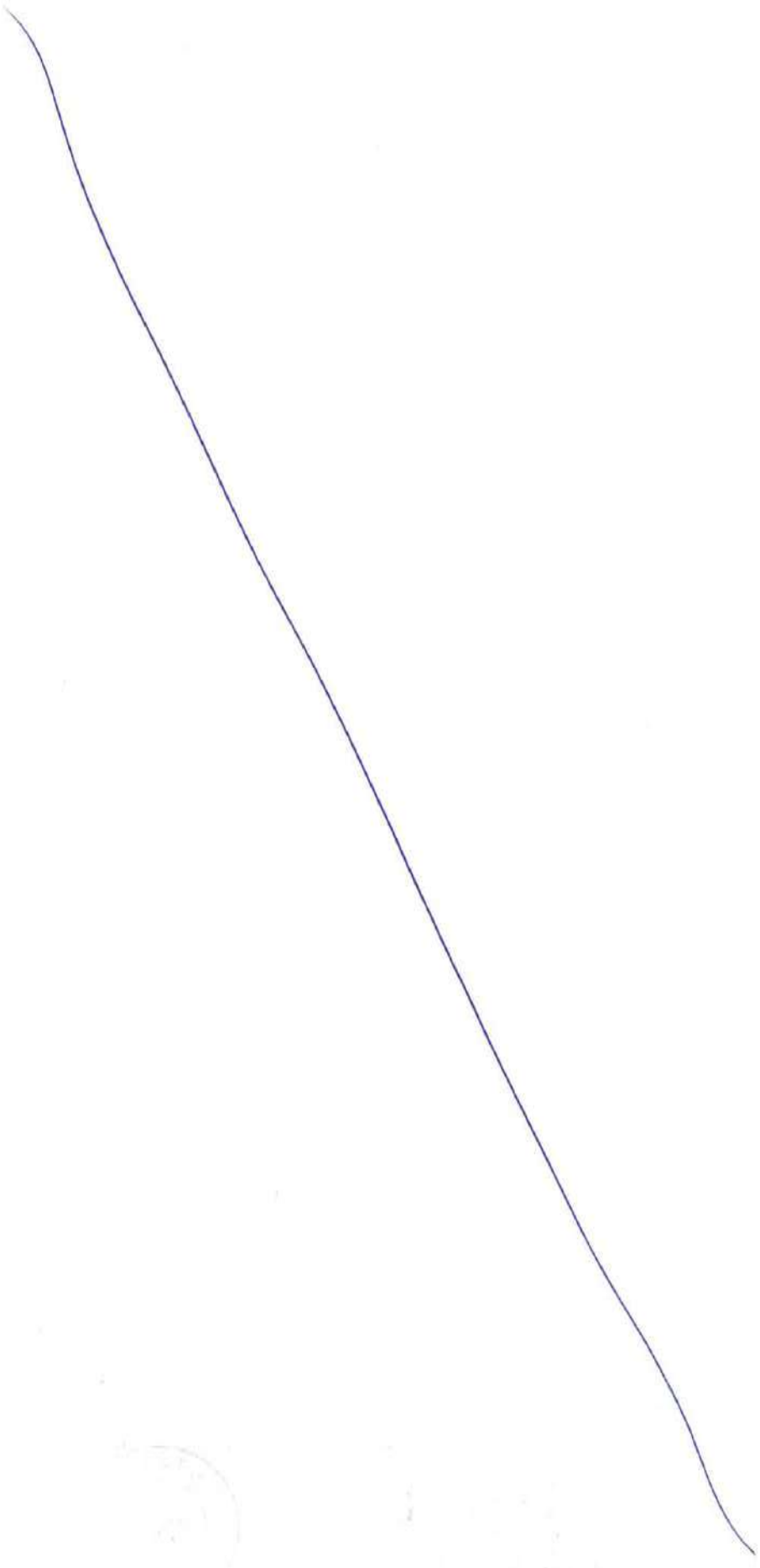

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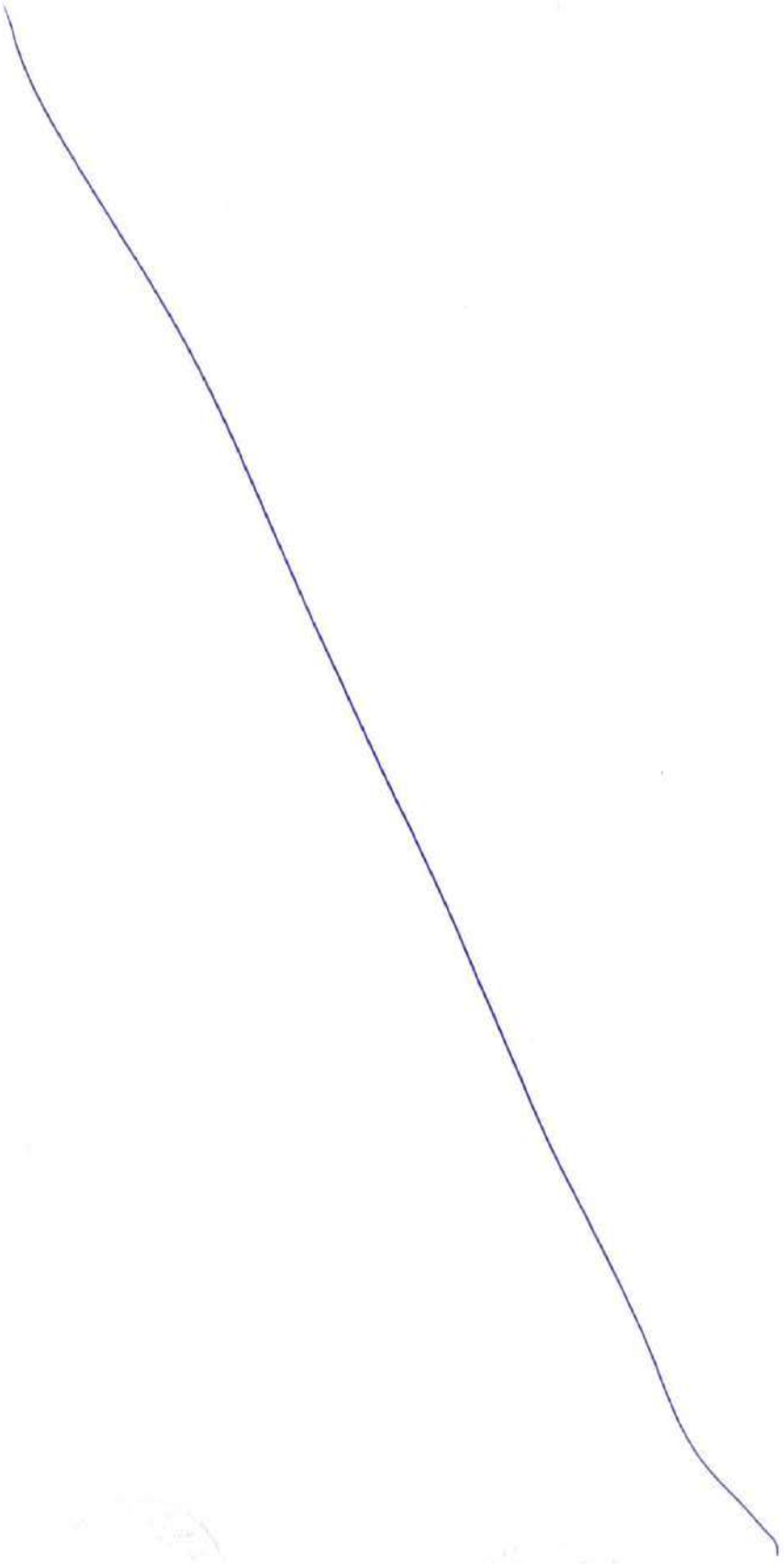


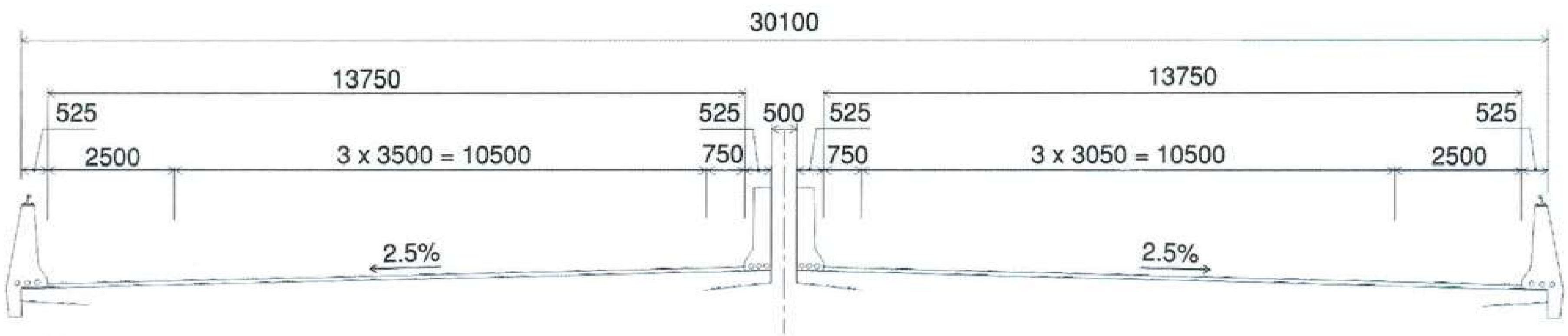


Figure 3-1 Functional cross section. Main carriageways, Ch 1+135 km to Ch 10+380 km (dimensions in mm)

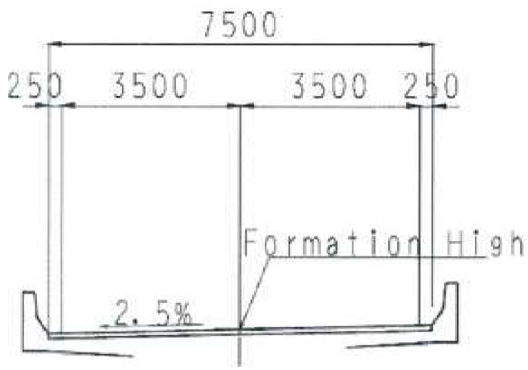


Figure 3-2 Functional cross section. Sewri Interchange ramps (dimensions in mm)

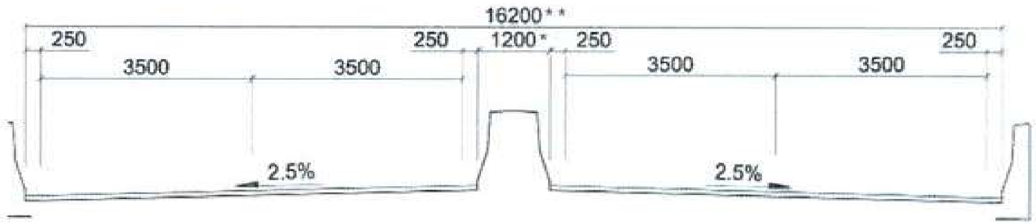
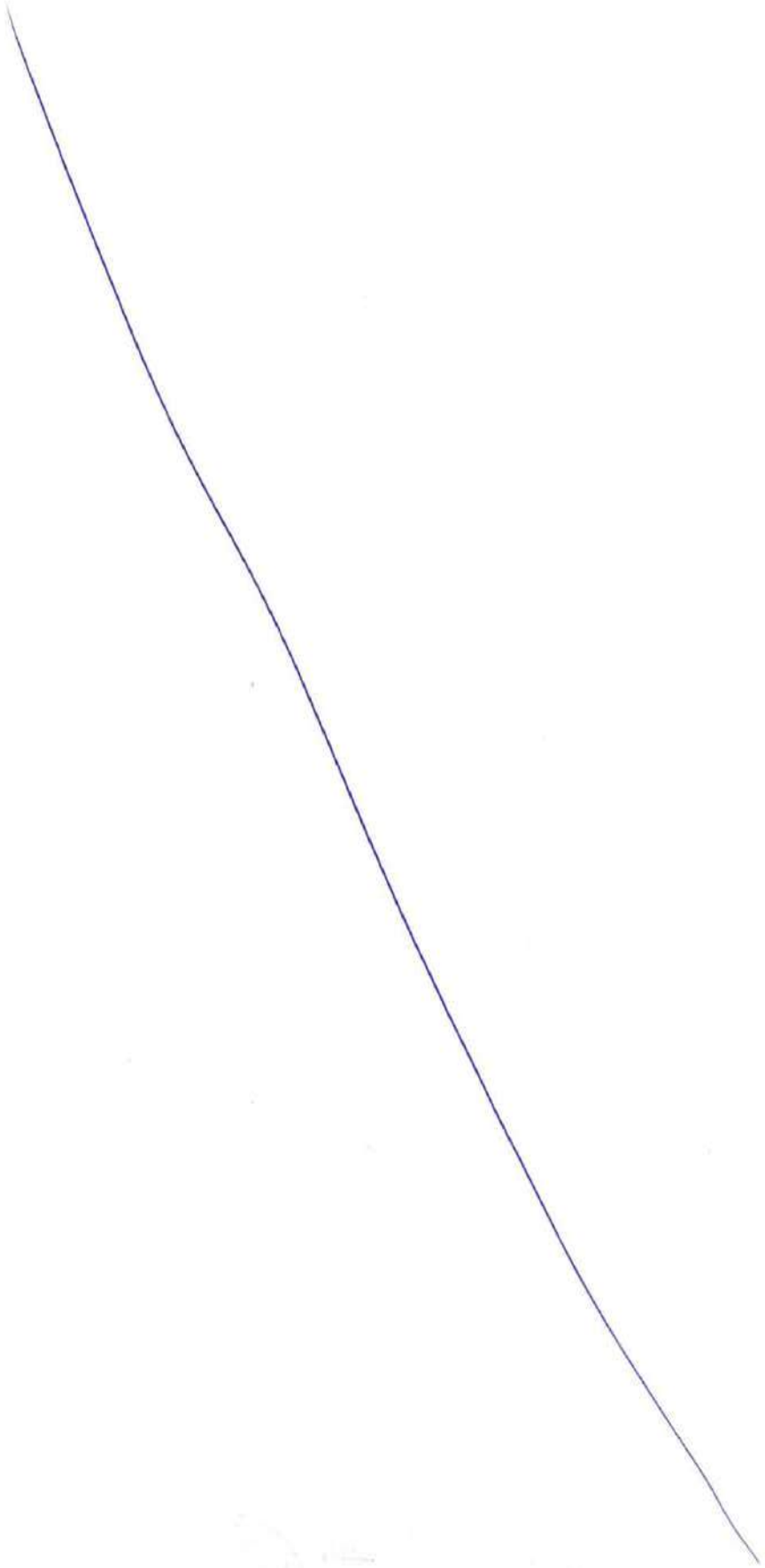


*Figure 3-3 Functional cross section. Main carriageways, Ch 0+000 km to Ch 0+495 km (dimensions in mm) (At Ch 0+495 km, * widens to 1550 / ** widens to 16350)*



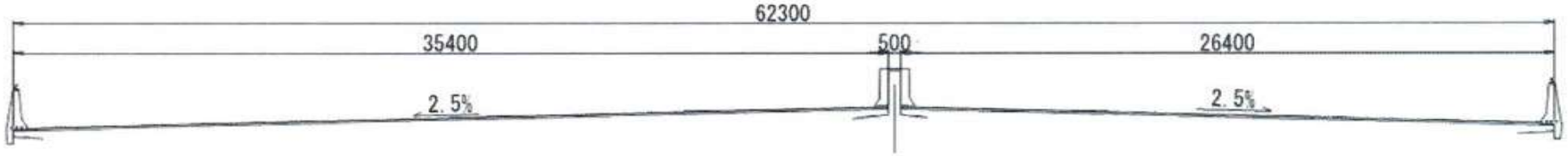


Figure 3-4 Sewri Interchange. Carriageway widths at Ch 0+500 km

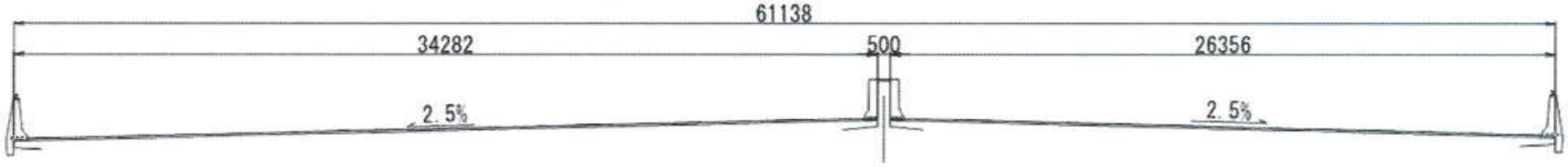


Figure 3-5 Sewri Interchange. Carriageway widths at Ch 0+600 km

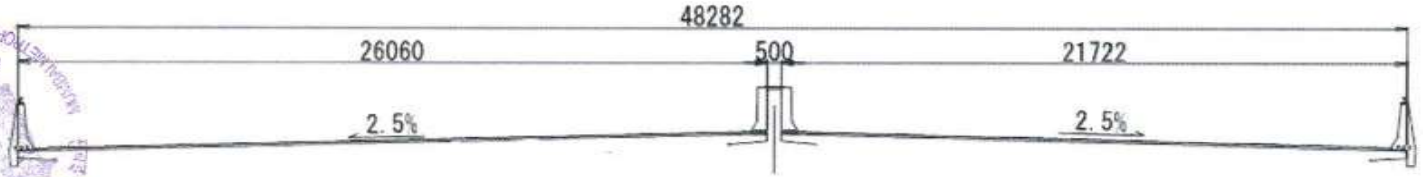
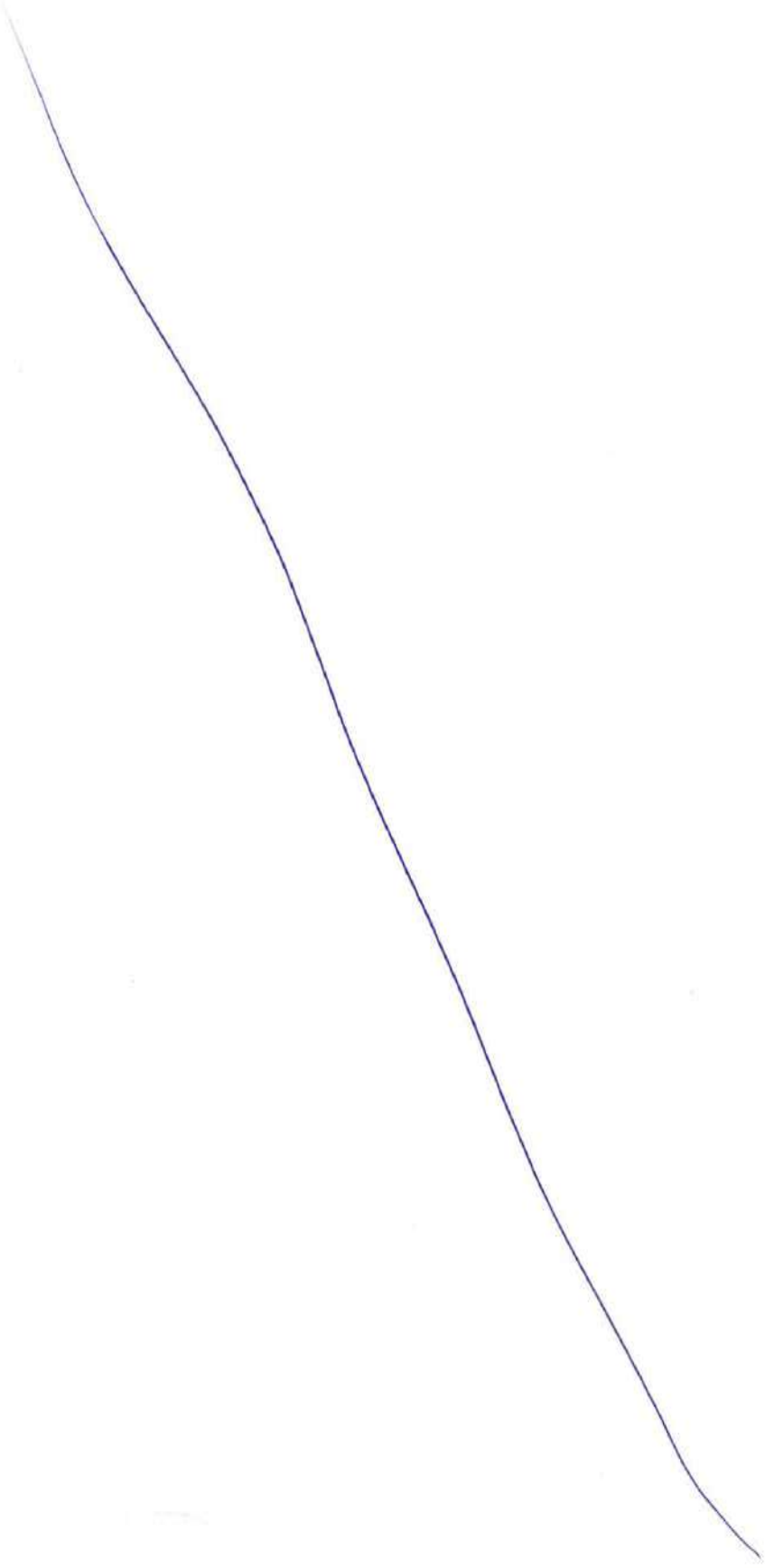


Figure 3-6 Sewri Interchange. Carriageway widths at Ch 0+750 km



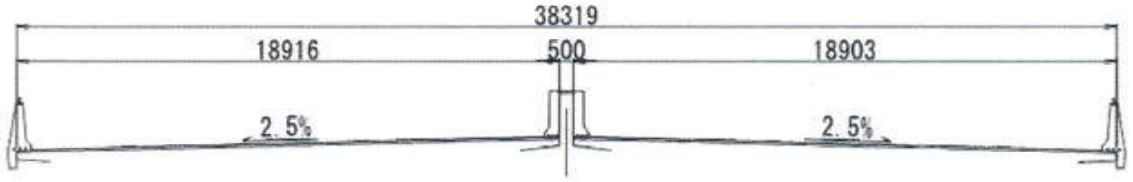


Figure 3-7 Sewri Interchange. Carriageway widths at Ch 0+850 km

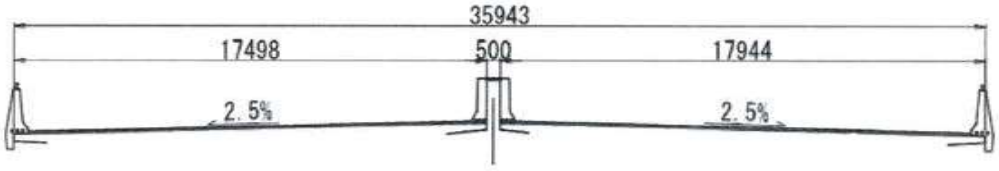


Figure 3-8 Sewri Interchange. Carriageway widths at Ch 0+950 km

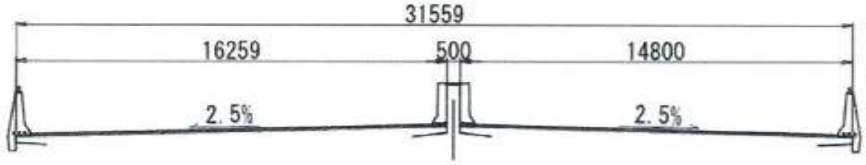


Figure 3-9 Sewri Interchange. Carriageway widths at Ch 1+050 km

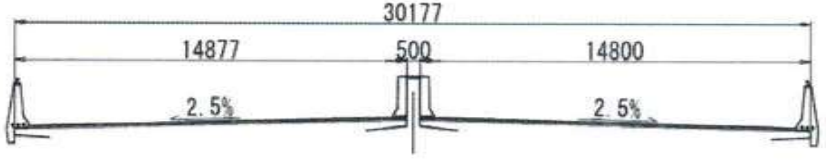
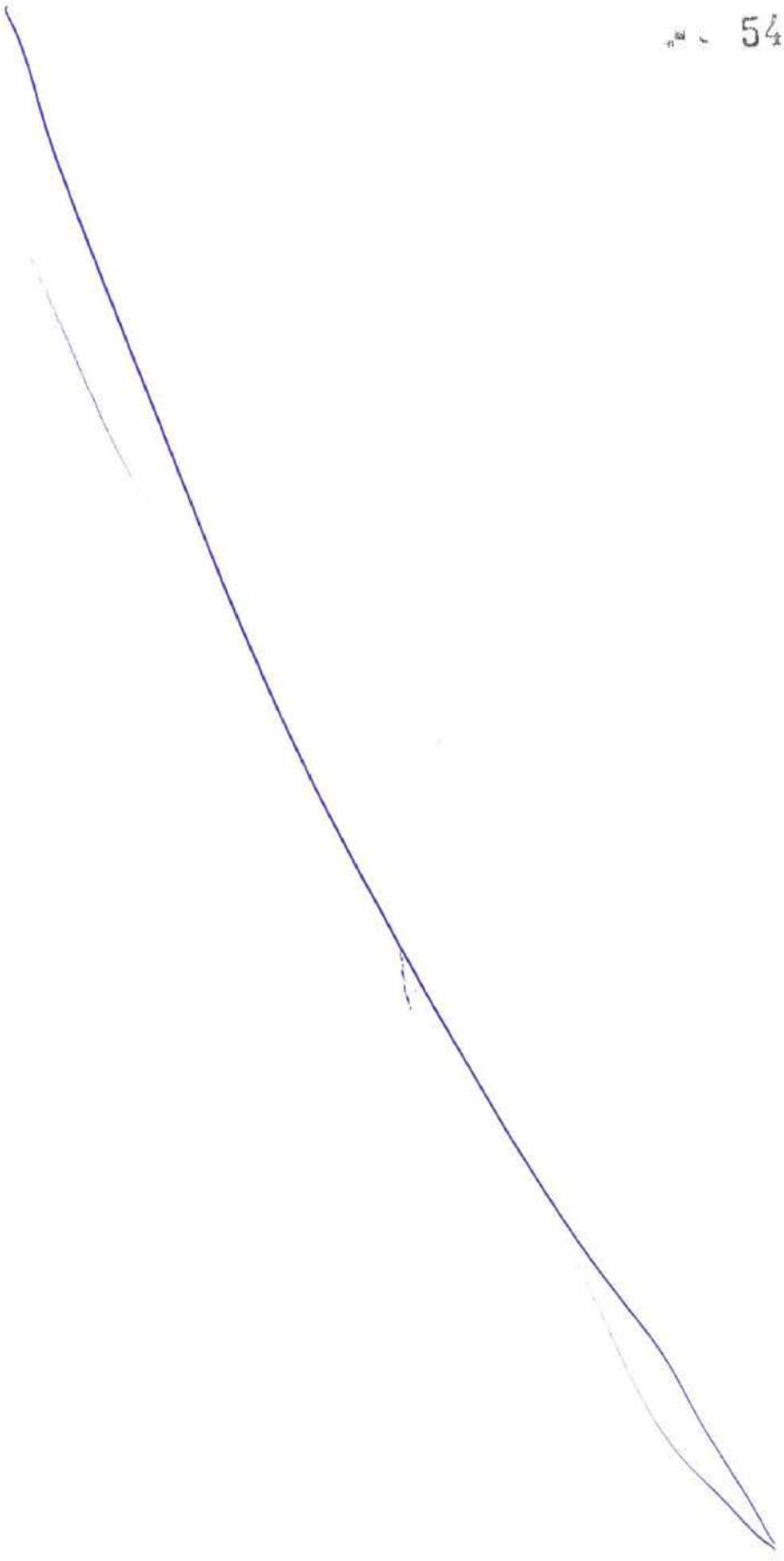


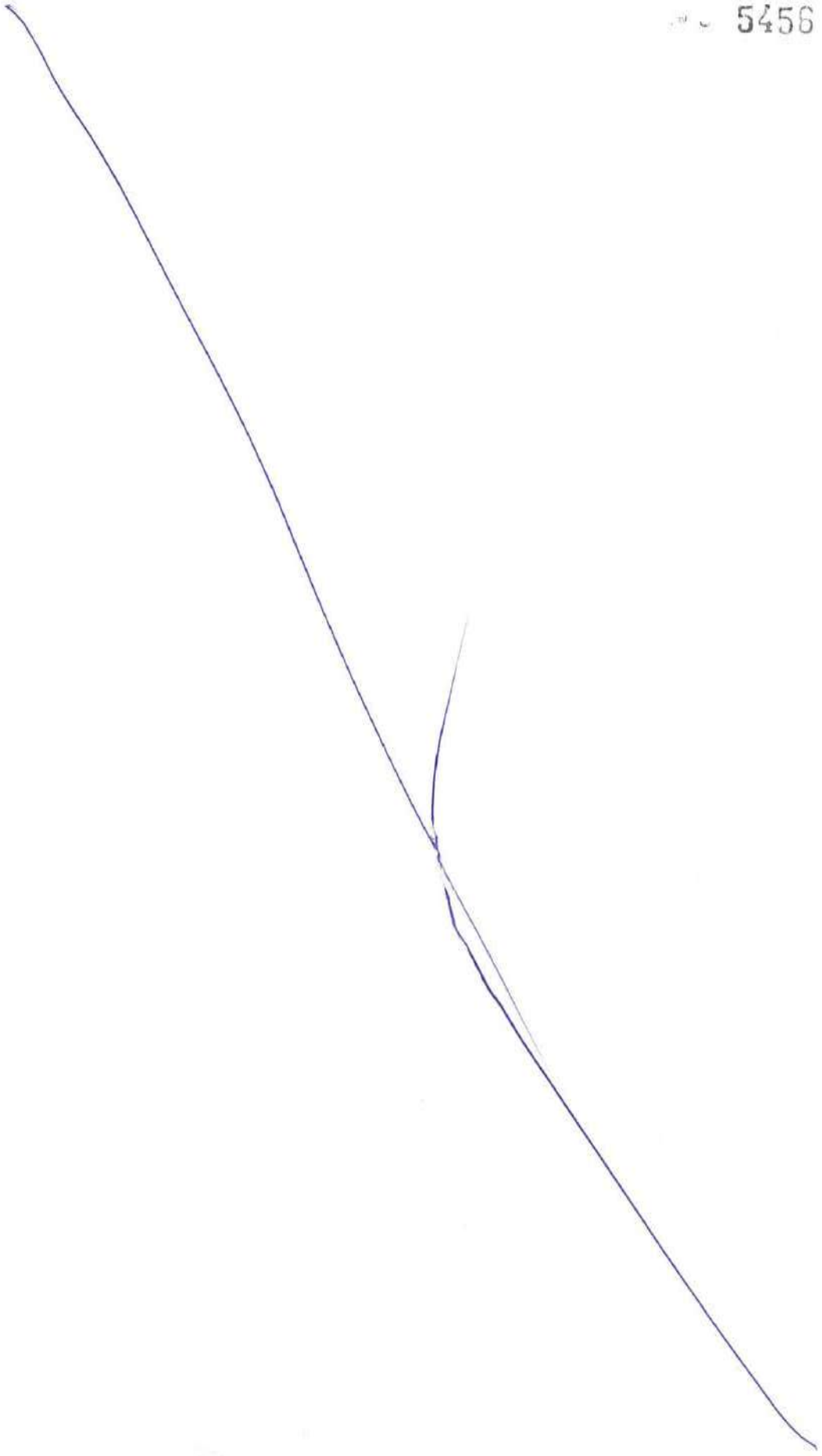
Figure 3-10 Sewri Interchange. Carriageway widths at Ch 1+100 km



3.5 HIGHWAY GEOMETRY

Limiting highway geometry shall be as follows:

- Main carriageway (ref. Employer's Requirements, §2.2, ERG-54)
  - Width of carriageways (3 lanes) : 3 x 3.50 m
  - Width of shoulders : 0.75 m (right), 2.50 m (left)
  - Width of central median : 1.55 m
  - Cross-fall : 2.5 %
  - Super-elevation (max.) : 6.0 %
  - Horizontal radius : 1,800 m
  - Vertical gradient (min.) : 0.5 %
  - Vertical gradient (max.) : 2.5 %
  - Length of vertical curve (min.) : 60 m
- Sewri Ramps (ref. Employer's Requirements, §2.3, ERG-54)
  - Width of carriageway (2 lanes) : 2 x 3.50 m
  - Width of shoulders : 0.25 m (both sides)
  - Cross-fall : 2.5%
  - Super-elevation (max.) : 7.0 %
  - Horizontal radius (min.) : 60 m
  - Longitudinal gradient (max.) : 3.3 % (except Ramp A)



3.6 CLEARANCES TO ROAD CROSSINGS

Existing and proposed roads crossing beneath the bridge and ramps are show in Table 3-1, as stated in the Employer's Requirements. A minimum vertical clearance of 5.5 m above the road surface shall be provided by the MTHL bridges.

Table 3-1 Crossing roads

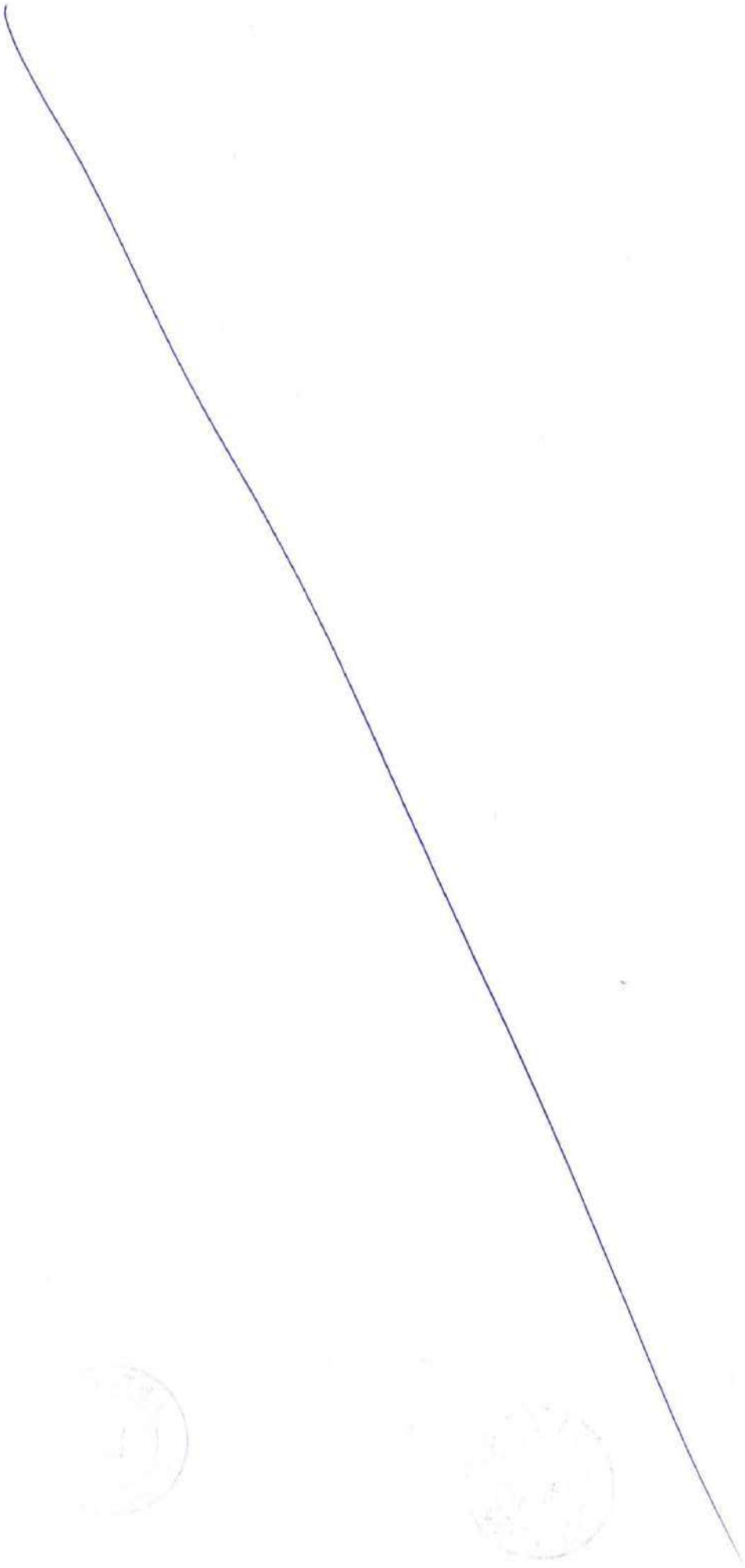
Crossing Road	Status	Chainage
Eastern Freeway	Existing	0+000
Jetty Road	Existing	0+480

3.7 NAVIGATION AND MARITIME CLEARANCES

Minimum vertical and horizontal clearances to navigation channels, port facilities, seabed installations and bridge spans shall be provided, as in Table 3-2.

Table 3-2 Minimum navigation and marine clearances to identified facilities

Location	Chainage	Horizontal Clearance	Vertical Clearance
Tata Thermal Power Station, Intake and Discharge Channel	3+560	1 x 94.6m (1 navigation spans)	31.0m above CD
Tata Thermal Power Station, Coal Berth Channel	4+830	2 x 94.6m (2 navigation spans)	31.0m above CD
Tata Power Cable (1 cable)	4+960	Comfortable separation distance is more than 25 m	Not applicable
ONGC Pipeline (2 pipelines)	5+270		



Tata/MbPT Pipeline (13 pipelines)	5+400 ~5+570	(minimum distance is 15 m)	
Pir Pau Jetty Head	5+800	Span arrangement to be agreed with MbPT	6.0m above jetty surface
Thane Creek	8+900	2 x 94.6 m (2 navigation spans)	31.0m above CD
Bridge spans (general)	-	50.0 m	14.9m above CD

3.8 UTILITIES

The marine viaduct bridges shall be provided with utility service troughs mounted inside the box girders, see Figure 3-11.

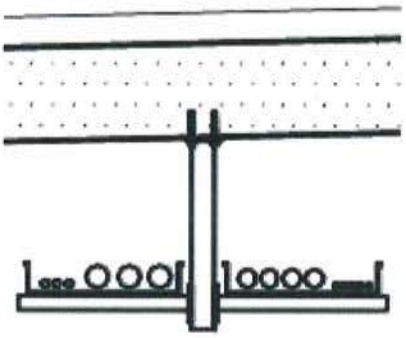
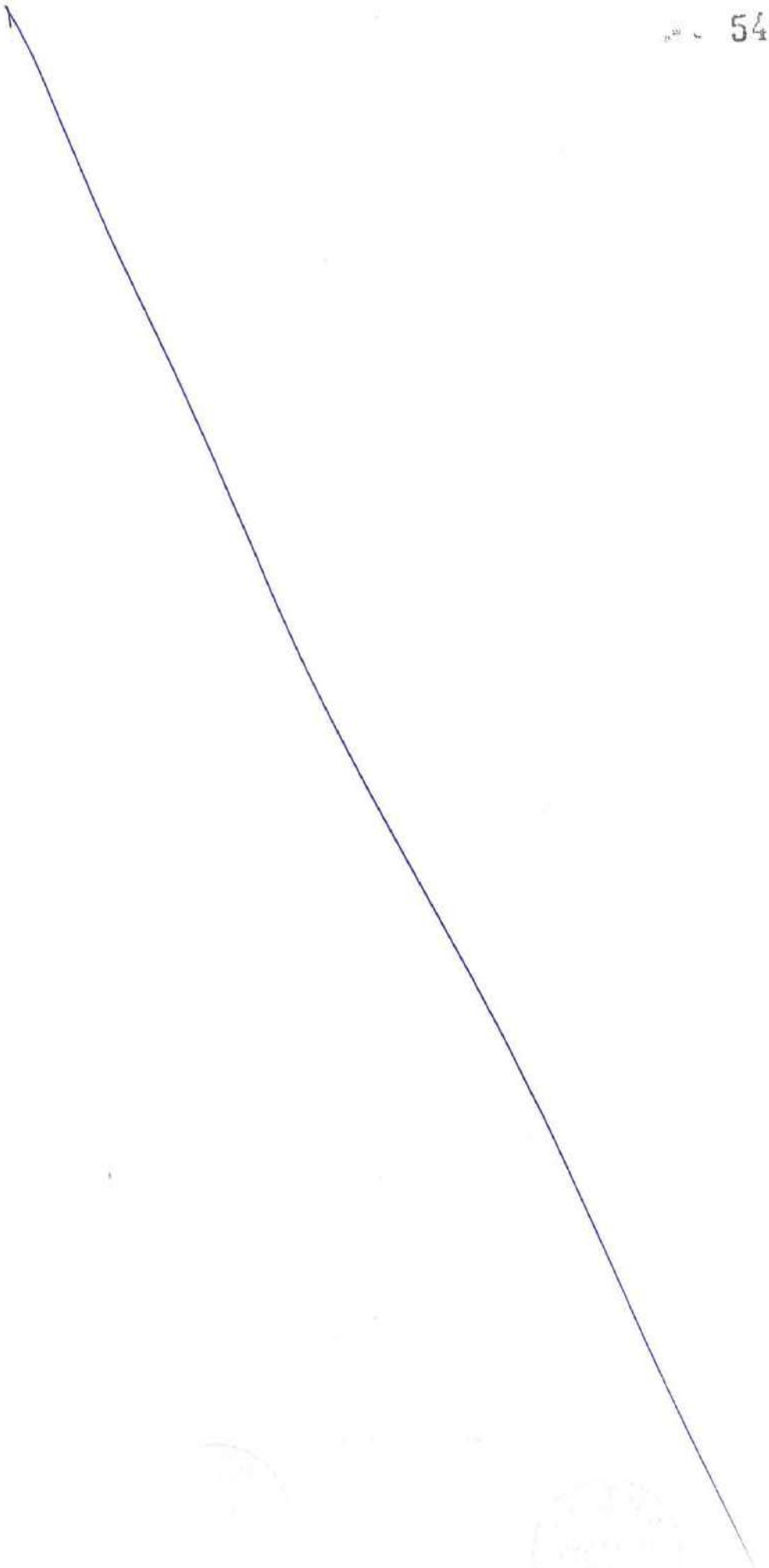


Figure 3-11 Utility trough

3.9 BARRIERS & FENCES

Vehicle crash barriers, noise barriers, view barriers and safety fences shall be provided as described in §11.4 and §11.5, below.



4 GENERAL DESIGN REQUIREMENTS

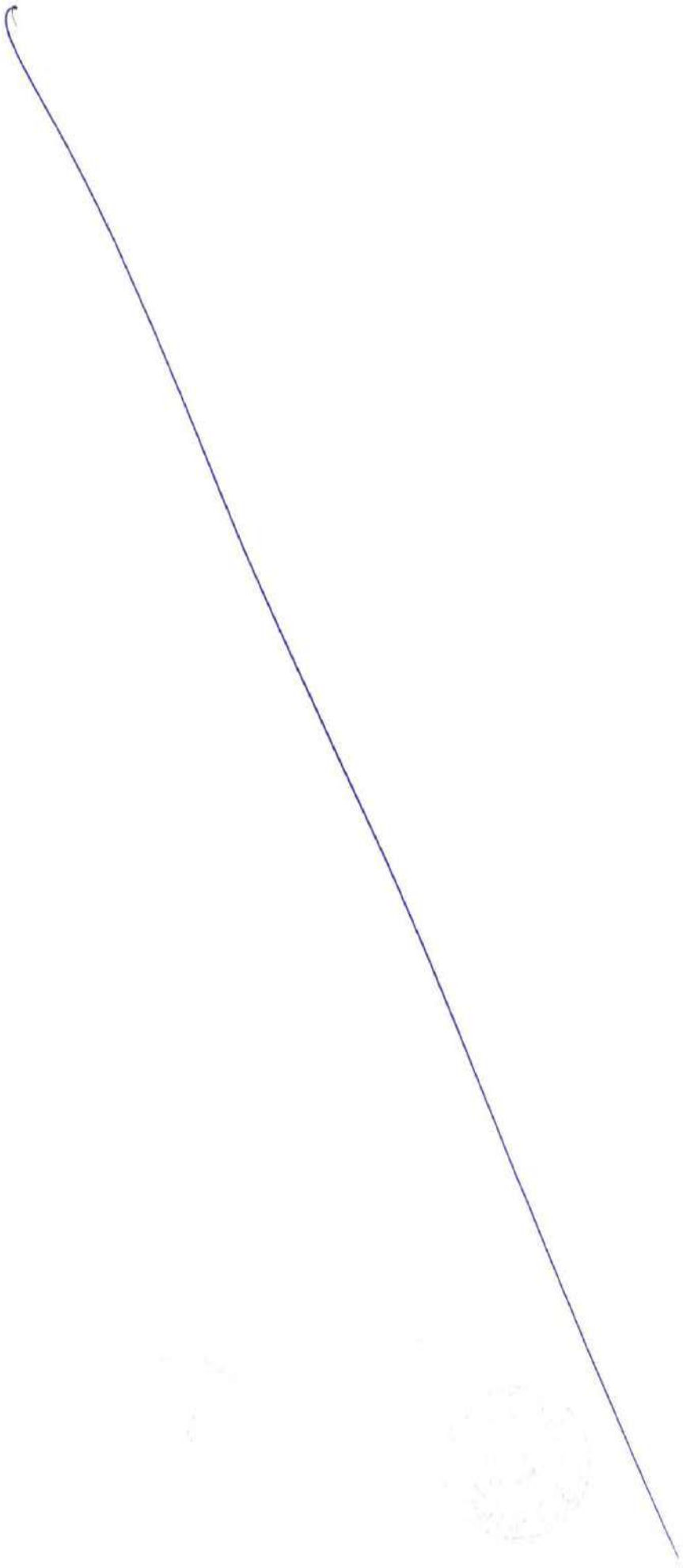
4.1 DESIGN SERVICE LIFE

The design service life of the MTHL shall be 100 years.

Certain elements may require replacement during the service life of the MTHL. The minimum target design service lives of the main components of the bridges are stated in Table 4-1.

Table 4-1 Minimum target design service lives

Bridge Component	Design Service Life (years)
Foundations	100
Piers	100
Deck	100
Bearings	40 (20 years for minor components only)
Expansion joints	20 (10 years for minor components only)
Parapets (metal parts only)	40
Parapets (concrete parts only)	100
Drainage system	20
Noise/view/safety barriers	40
Bridge deck waterproofing	20
Bridge deck surfacing	20
Walkways and other bridge furniture	20



5 LOADING

Loadings shall be as defined in IRC:6-2017, unless stated otherwise in this document.

5.1 PERMANENT LOADS

Structure dead loads (DL)

The following characteristic unit weights of materials shall be used:

- High Performance Concrete (2.6 t/m³) : 25.5 kN/m³
- Structural steel (rolled or cast) (7.85 t/m³) : 77.0 kN/m³

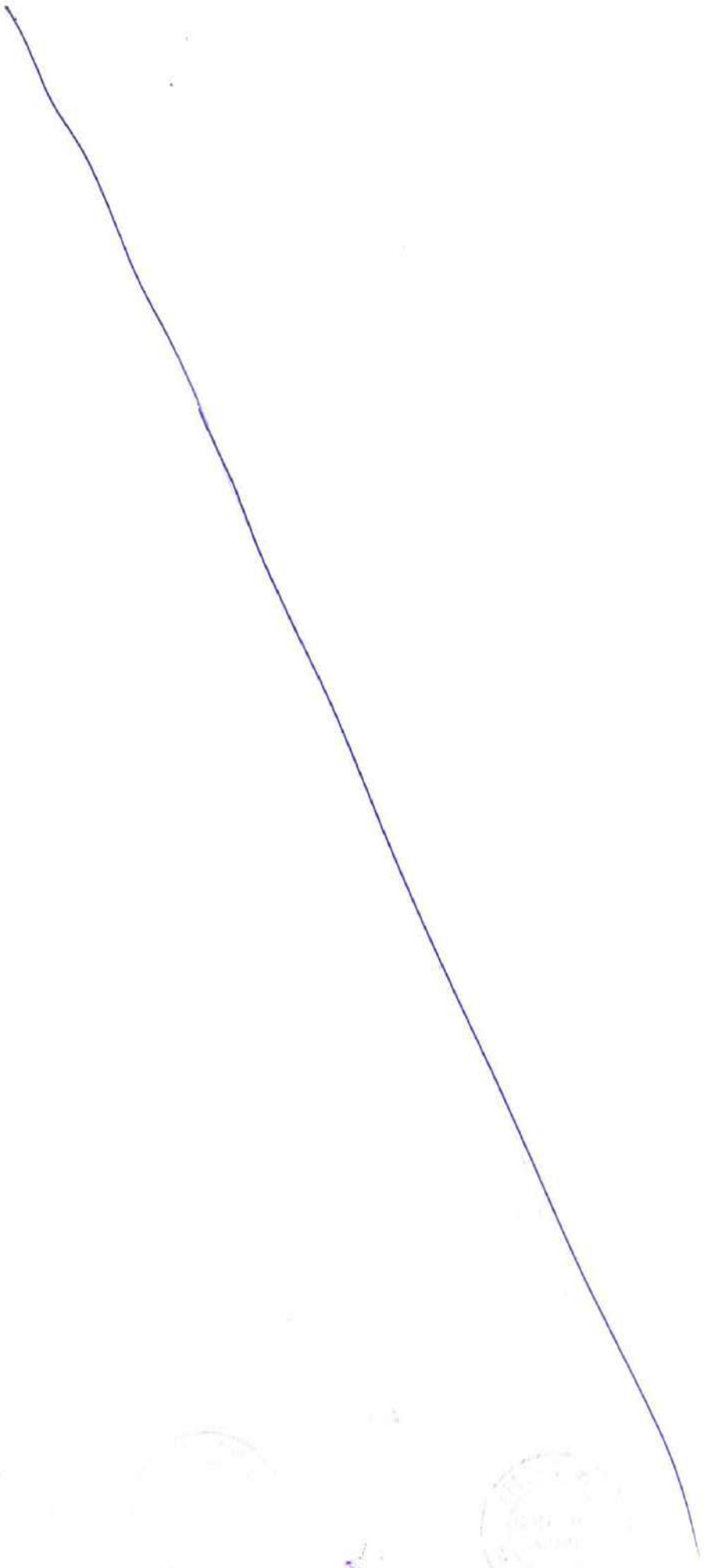
Superimposed dead loads (SIDL)

The weights of all materials forming loads on the structure that are not structural elements shall be regarded as Superimposed Dead Loads.

The following characteristic unit weights/loads shall be used:

- Carriageway bituminous surfacing (2.2 t/m³) : 21.6 kN/m³

  For 80 mm thick surfacing, UDL = 0.08 x 21.6 = 1.74 kN/m²
- Crash barrier (outer) UDL = 0.81 x 25.5 = 20.7 kN/m
- Crash barrier (median) UDL = 0.59 x 25.5 = 15.1 kN/m
- Noise barrier/visual barrier/safety barrier (add. to crash barrier) : 1.0 kN/m each
- Utility trough inside box girder (self-weight) : 0.5 kN/m each
- Walkway inside box girders, 1 m wide (self-weight) each : 1.5 kN/m
- Utility loads (lighting, emergency telephones & fire hydrants),



- At outer parapet : 5.0 kN/m each
- At median parapet : 5.0 kN/m each

- Allowance for double flaps and cowlings for aerodynamic stability (VIV) to all steel girder spans : 2.5 kN/m
- Allowance for horizontal plates for aerodynamic stability (galloping) to steel girders with spans exceeding 120 m : 0.7 kN/m
- Inspection gantry self-weight : to be confirmed

Differential settlement

A total differential settlement of 20 mm between two adjacent piers is considered for Tender Design, in accordance with Employer's Requirements, section 3.1.3.2 (ERG-65).

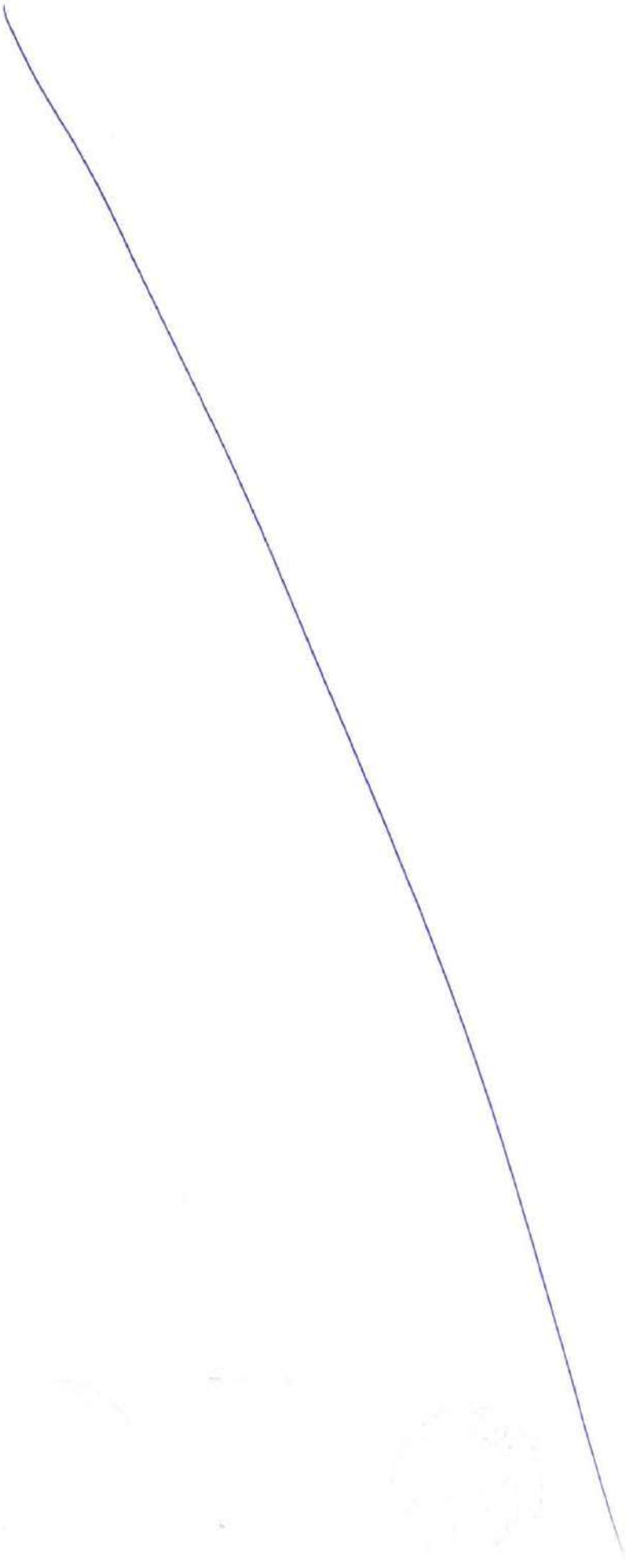
Pre-stressing (P)

Actions due to pre-stressing shall be determined in accordance with IRC:112-2011, 7.9.

For the calculation of initial pre-stressing losses the constants in Table 5-1 shall be used.

Table 5-1 Constants for calculation of immediate pre-stress losses

	Tendons		Bars
	Internal	External	Internal
Duct type	HDPE	HDPE	HDPE
Duct friction coefficient, μ	0.17 /radian	0.17 /radian	0.65 /radian
Wobble coefficient, k	0.002 radian/m	0 (zero)	0.0025 radian/m



Wedge/Anchor Draw-in	6 mm	6 mm	0.7 mm (40/50 mm) 1.0 mm (75 mm)

Time-dependent pre-stress losses (creep, shrinkage) shall be determined in accordance with IRC:112-2011, §6.4.2.6 and §6.4.2.7.

5.2 VEHICLE LIVE LOAD

Road traffic loads shall be in accordance with IRC:6-2017, unless stated otherwise in this document.

Vertical traffic loads

General

The design live load shall consist of standard wheeled or tracked vehicles or trains of vehicles as described in this section.

Within the kerb to kerb width of the roadway, the standard vehicle or train shall be assumed to travel parallel to the length of the bridge and to occupy any position which will produce maximum stresses, provided that the minimum clearances between a vehicle and the roadway face of kerb and between two passing or crossing vehicles, defined below, are not encroached upon.

For each standard vehicle or train, all the axles of a unit of vehicles shall be considered as acting simultaneously in a position causing maximum stresses.

All bridges and ramps shall be classified as IRC Class 70R Loading (ref. IRC:6-2017, §201.1).

Design lanes

The numbers of lanes and the live load combinations to be considered for design purposes shall be determined in accordance with Table 5-2. The application of lanes for design purposes to the Main Bridge and Interchange ramps shall be in accordance with

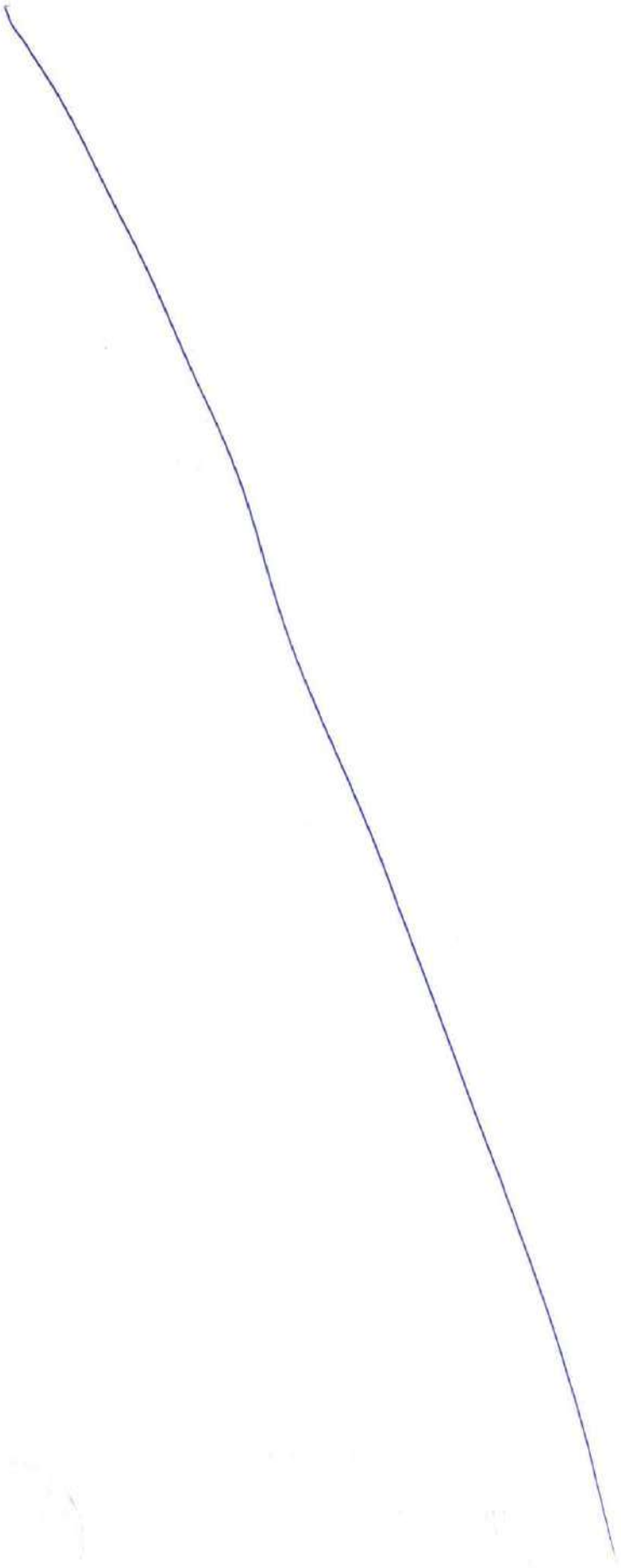


Table 5-3 and

Table 5-4.

Table 5-2 Design lanes [1]

Carriageway Width (CW)	Number of Lanes for Design Purposes
Less than 5.3 m	1
5.3 m and above but less than 9.6 m	2
9.6 m and above but less than 13.1 m	3
13.1 m and above but less than 16.6 m	4
16.6 m and above but less than 20.1 m	5
20.1 m and above but less than 23.6 m	6
23.6 m and above but less than 27.1 m	7
27.1 m and above but less than 30.6 m	8
30.6 m and above but less than 34.1 m	9
34.1 m and above but less than 37.6 m	10
Note 1. This table is based on IRC:6-2017, Table 6, extended to suit the requirements of the MHTL.	

The application of lanes for design purposes to the main bridge and interchange ramps shall be in accordance with

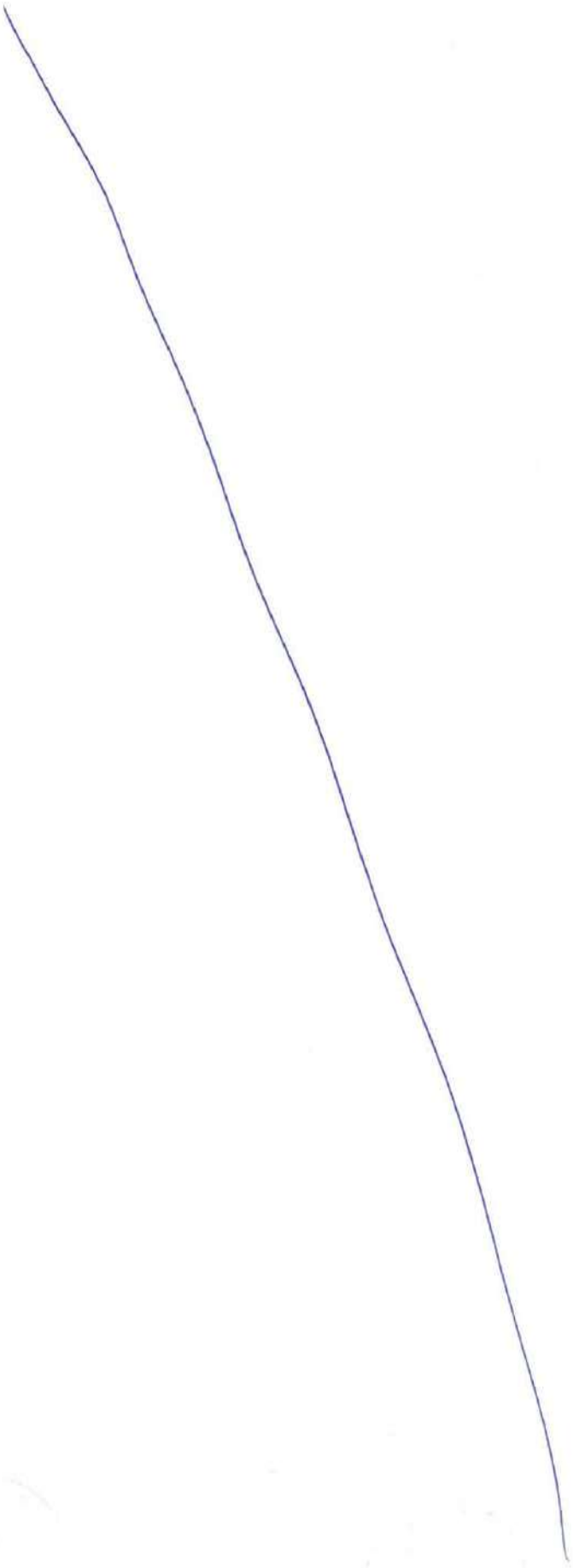
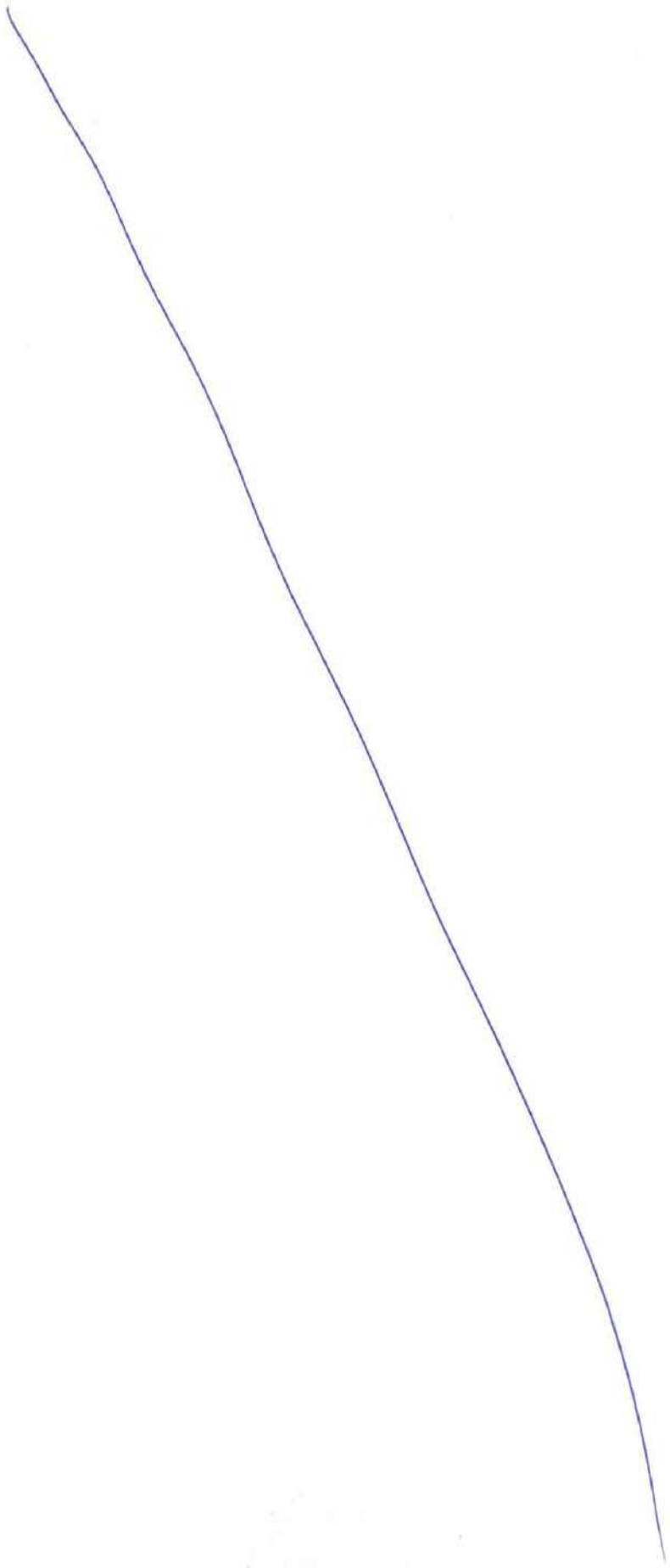


Table 5-3 and
Table 5-4.

Table 5-3 Application of design lanes

Structure	Chainage (km)	Carriageway Width(s) (CW) (m)	No. of Lanes for Design Purposes

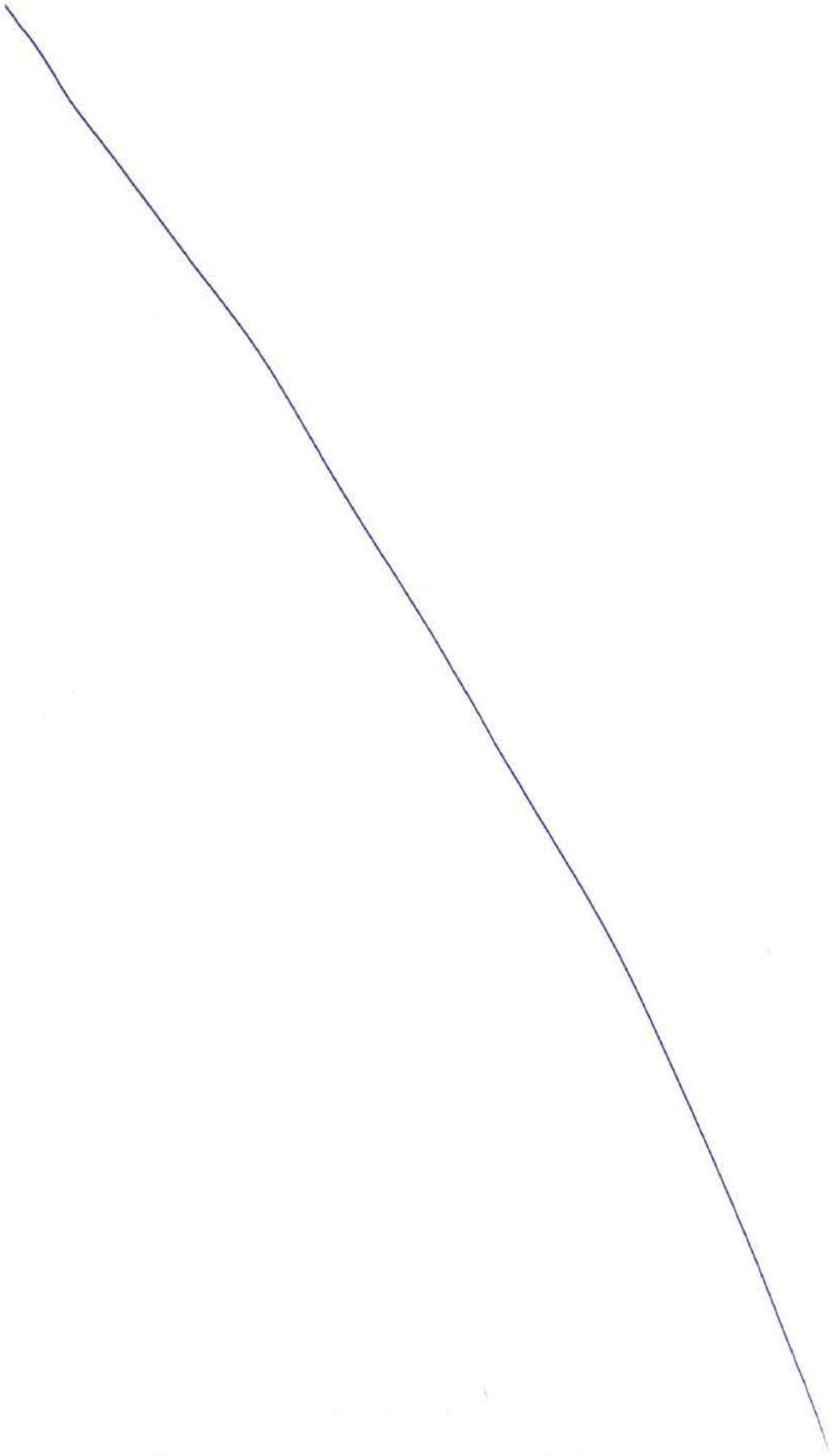


Main Bridge		0+000 – 0+495	2 x 7.5	2 + 2
		0+495 – 1+135	See Table 5-4	
		1+135 – 10+380	2 x 13.75 [1]	2 x 4 [1]
Sewri Interchange ramps	A	-0+197.200 – 1+500.800	7.5	2
	B	0+005.010 – 1+535.010	7.5	2
	C1	0+265.680 – 1+205.680	7.5	2
	C2	0+005.000 – 0+505.000	7.5	2
	E	-0+140.146 – 0+767.854	7.5	2
	F	0+250.400 – 0+630.400	7.5	2

Note 1. The two carriageways of Main Bridge are structurally independent and are to be considered separately, except for Main Bridge carriageway, Ch. 0+000 to 0+495 km.

Table 5-4 Application of design lanes Ch 0+495 km to Ch 1+135 km

Structure	Spans	Chainage (km)	Carriageway Width(s) (CW) (m)	No. of Lanes for Design Purposes
Main Bridge (North) (direction towards Navi Mumbai)	MP1 – MP3	0+495 – 0+595	34.350 – 33.240	10
	MP3 – MP4	0+595 – 0+655	33.240 – 30.435	9
	MP4 – MP5	0+655 – 0+715	30.435 – 26.925	8
	MP5 – MP6	0+715 – 0+775	26.925 – 22.990	7
	MP6 – MP7	0+775 – 0+835	22.990 – 18.630	6



	MP7 – MP8	0+835 – 0+895	18.630 – 16.500	5
	MP8 – MP12	0+895 – 1+135	16.500 – 13.750	4
Main Bridge (South) (direction towards Sewri/Mumbai)	MP1 – MP5	0+495 – 0+715	25.350 – 22.040	7
	MP5 – MP6	0+715 – 0+775	22.040 – 19.545	6
	MP6 – MP9	0+775 – 0+955	19.545 – 16+610	5
	MP9 – MP11	0+955 – 1+075	16.610 – .13.750	4
	MP11 – MP12	1+075 – 1+135	13.750	4

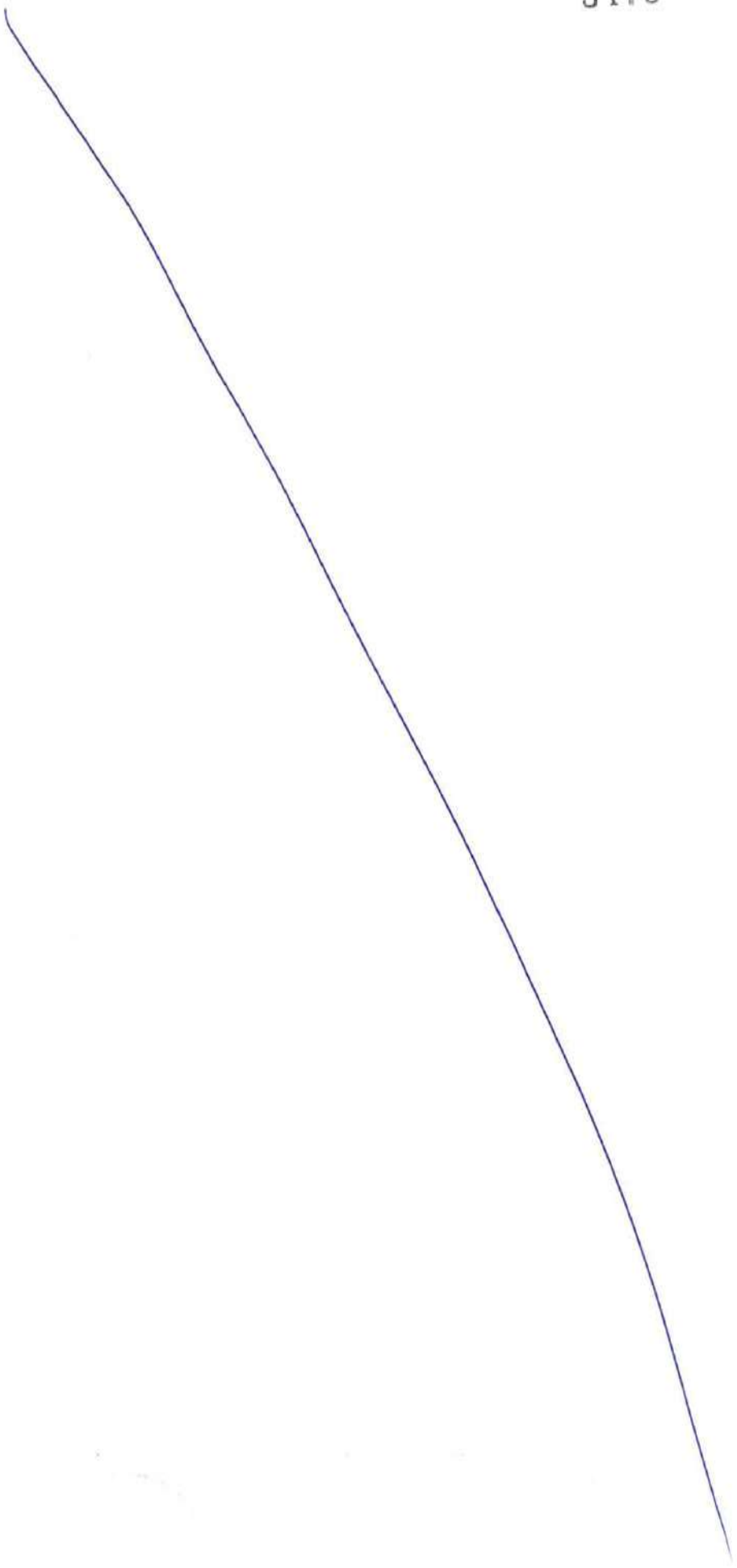
Live load combinations

The combinations of live loads to be considered for design purposes shall be in accordance with IRC:6-2017, Table 6, as summarised in

Table 5-5.

Table 5-5 Live load combinations

Structure	No. of Lanes for Design Purposes	Live load combinations
Main Bridge	2	One lane of Class 70R OR two lanes of Class A
	4 - 10	One lane of Class 70R for every two lanes with one lane of Class A for the remaining lanes, OR one lane of Class A for each lane
Interchange ramps	2	One lane of Class 70R OR two lanes of Class A



Examples of the arrangement of live load combinations positioned on carriageways with 2, 4 ,5 and 6 design lanes are given in Figure 5-1, Figure 5-2, Figure 5-3 and Figure 5-4, respectively.

For carriageways with 7- 10 design lanes, live load combinations shall be positioned by extending the principles shown for carriageways with 4, 5 and 6 lanes.

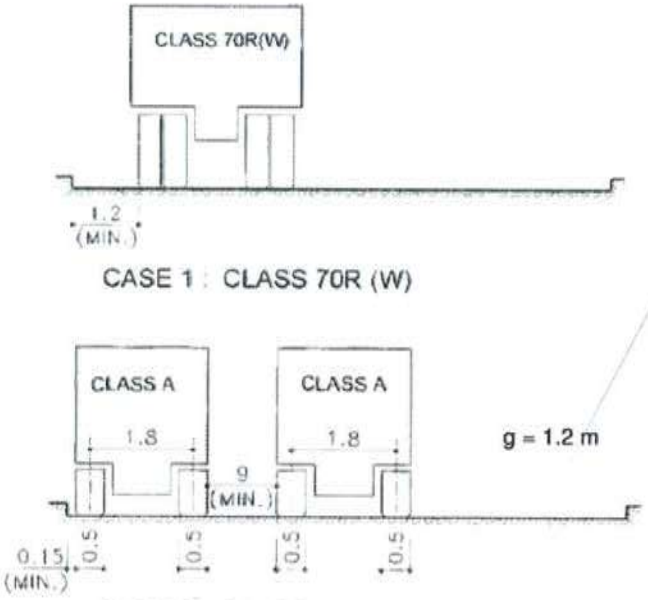
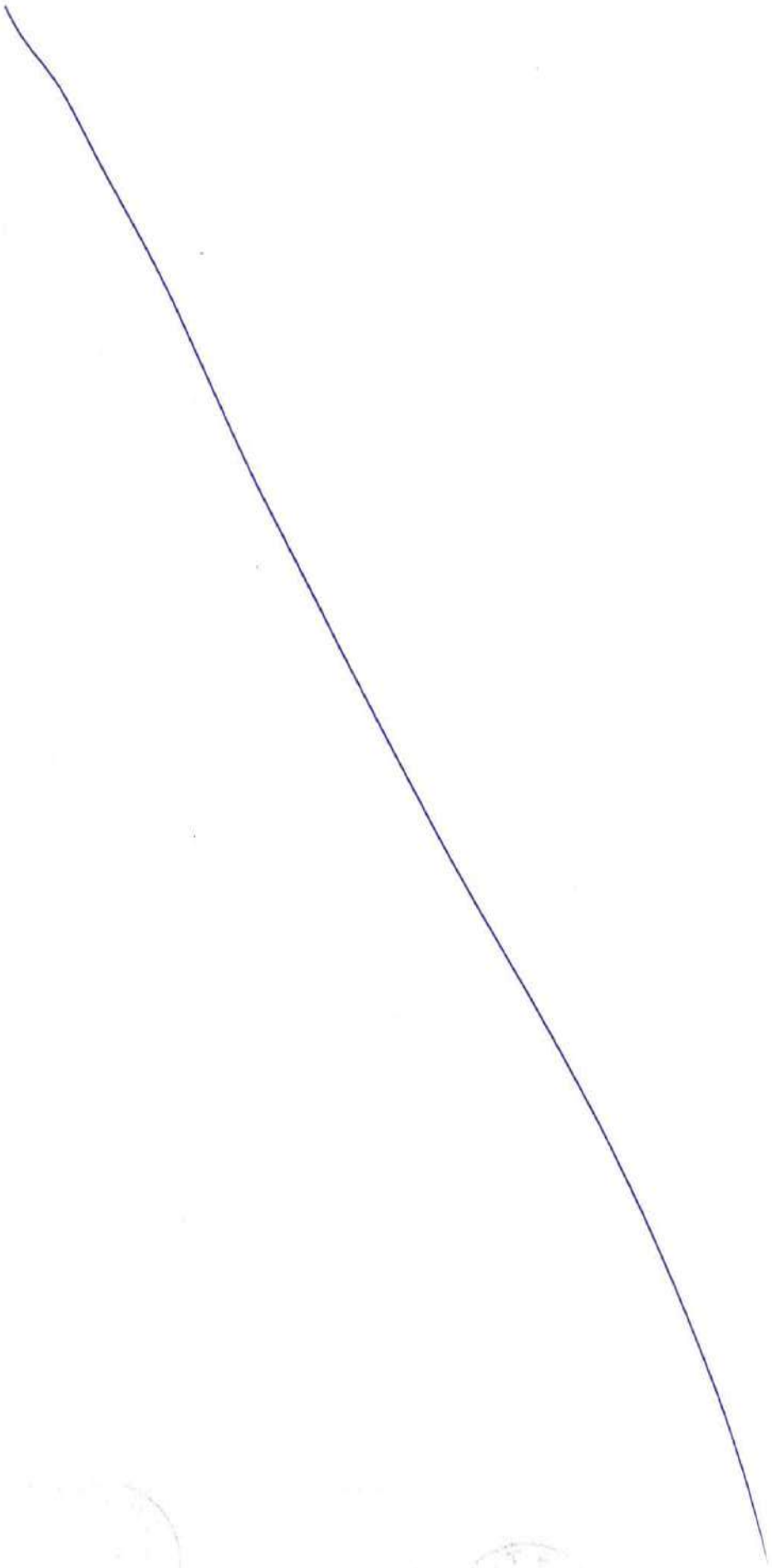
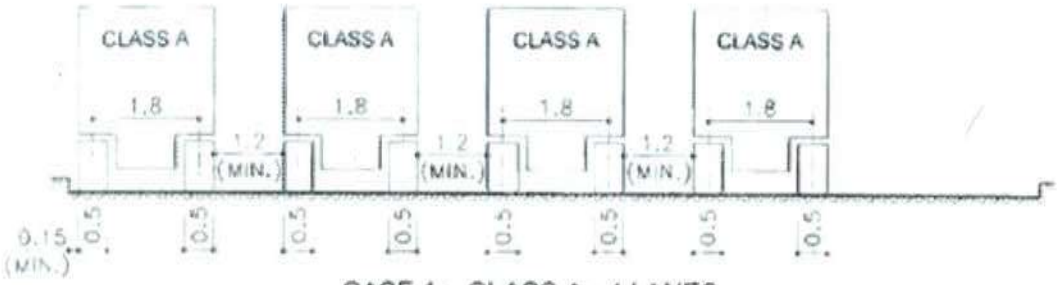
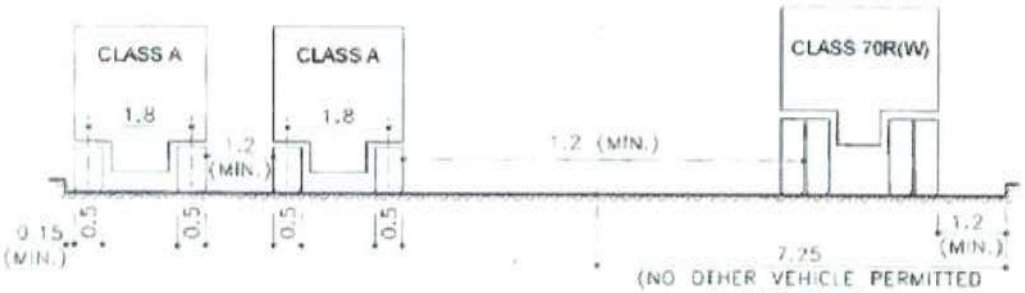


Figure 5-1 Examples of live load combinations for carriageway with 2 design lanes

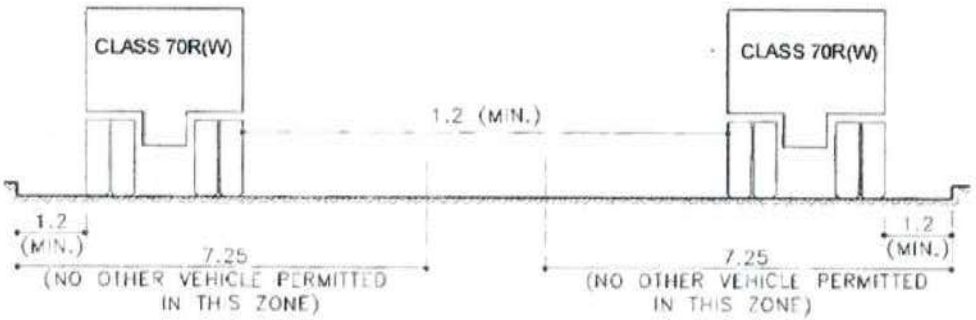




CASE 1 : CLASS A - 4 LANES

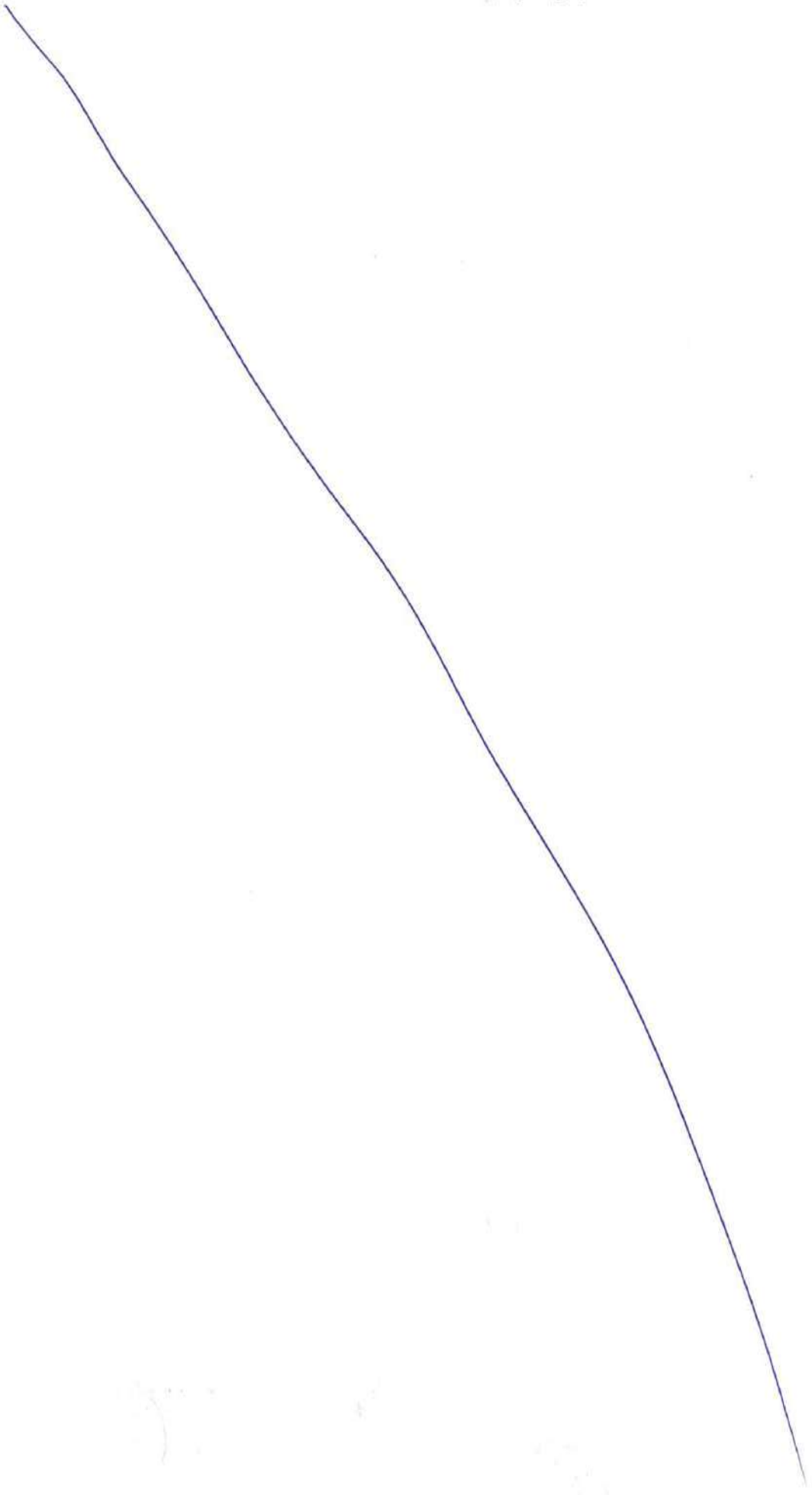


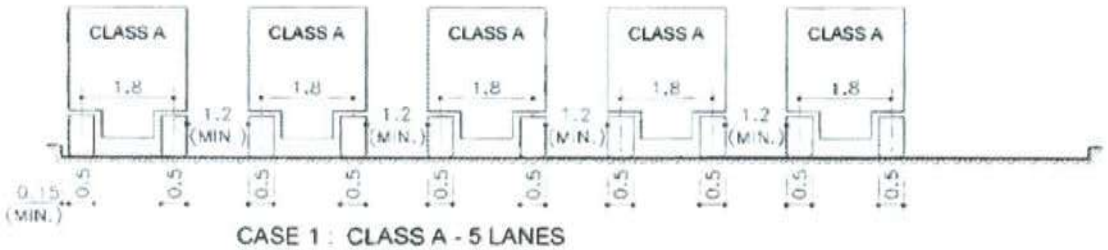
CASE 2 : CLASS A - 2 LANE +CLASS 70R (W)



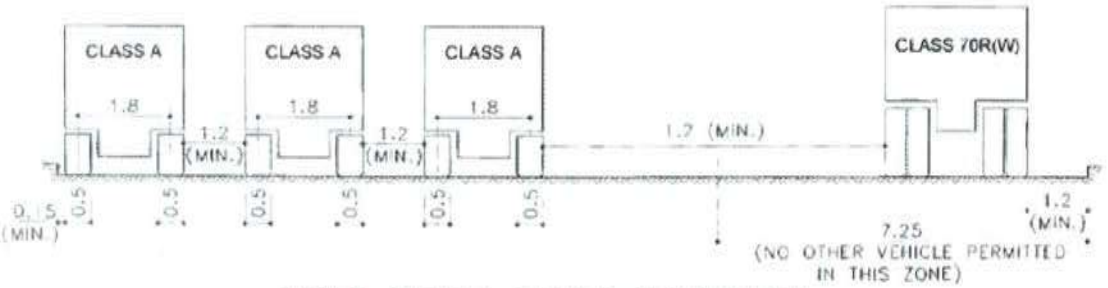
CASE 3 : CLASS 70R (W) - 2 LANES

Figure 5-2 Examples of live load combinations for carriageway width 4 design lanes

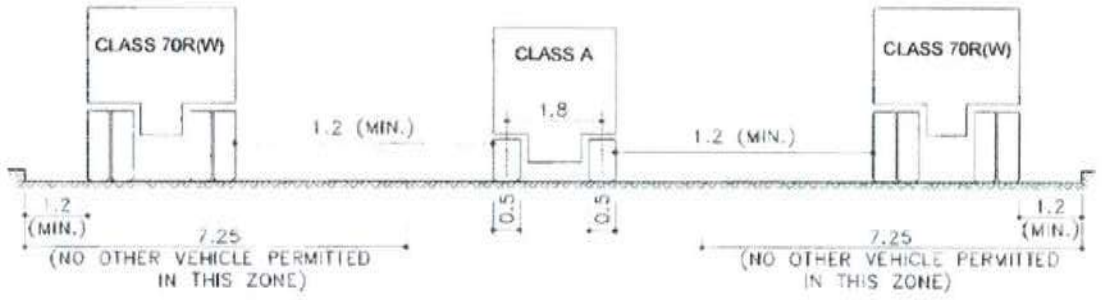




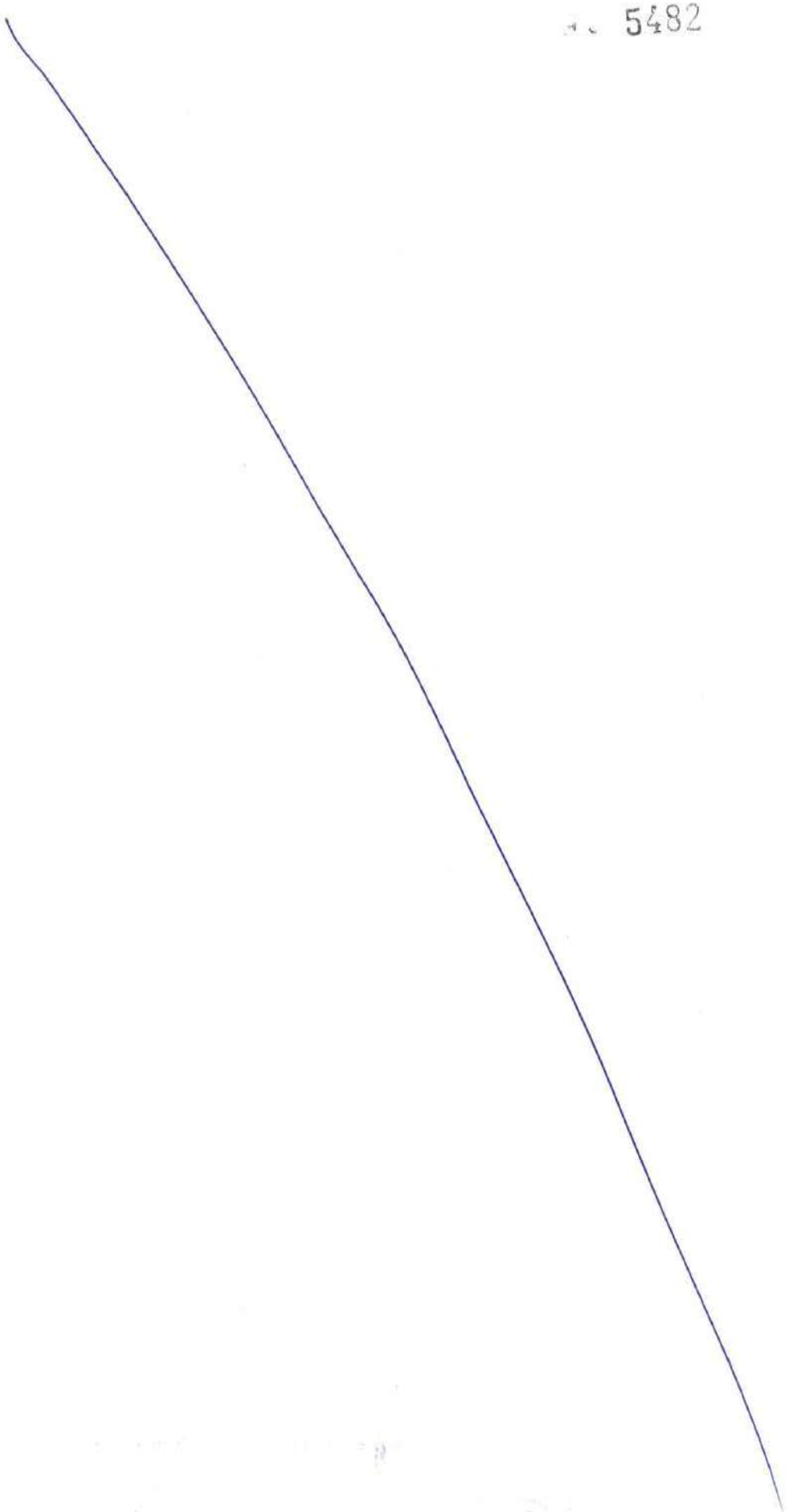
CASE 1 : CLASS A - 5 LANES

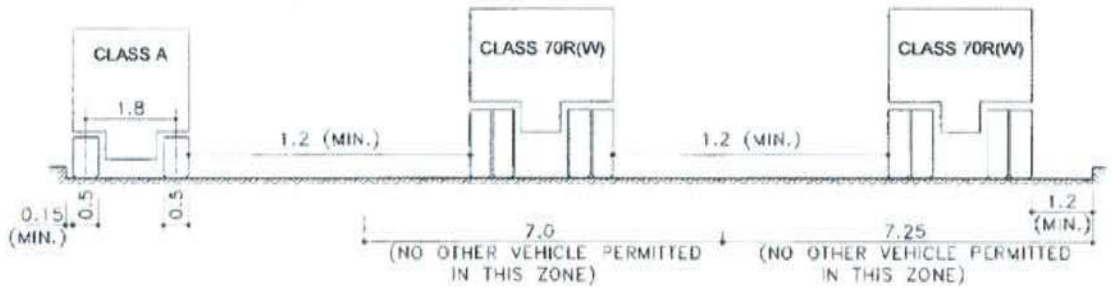


CASE 2 : CLASS A - 3 LANES +CLASS 70R (W)



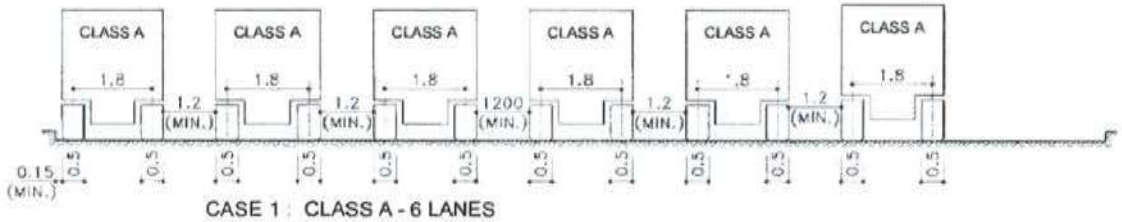
CASE 3 : CLASS 70R (W) - 2 LANES + CLASS A -1 LANE



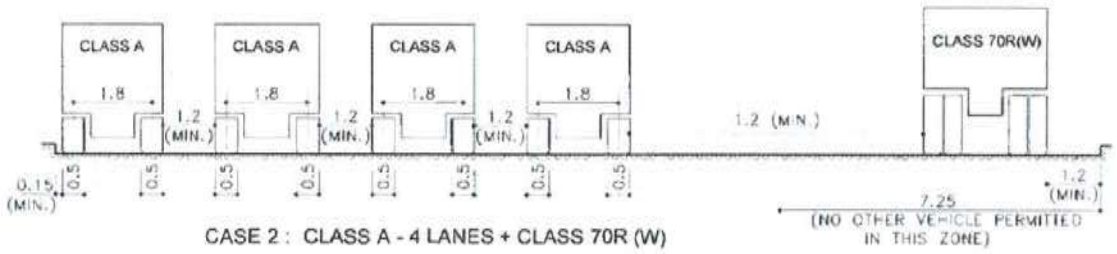


CASE 4 : CLASS A -1 LANE + CLASS 70R (W) - 2 LANES

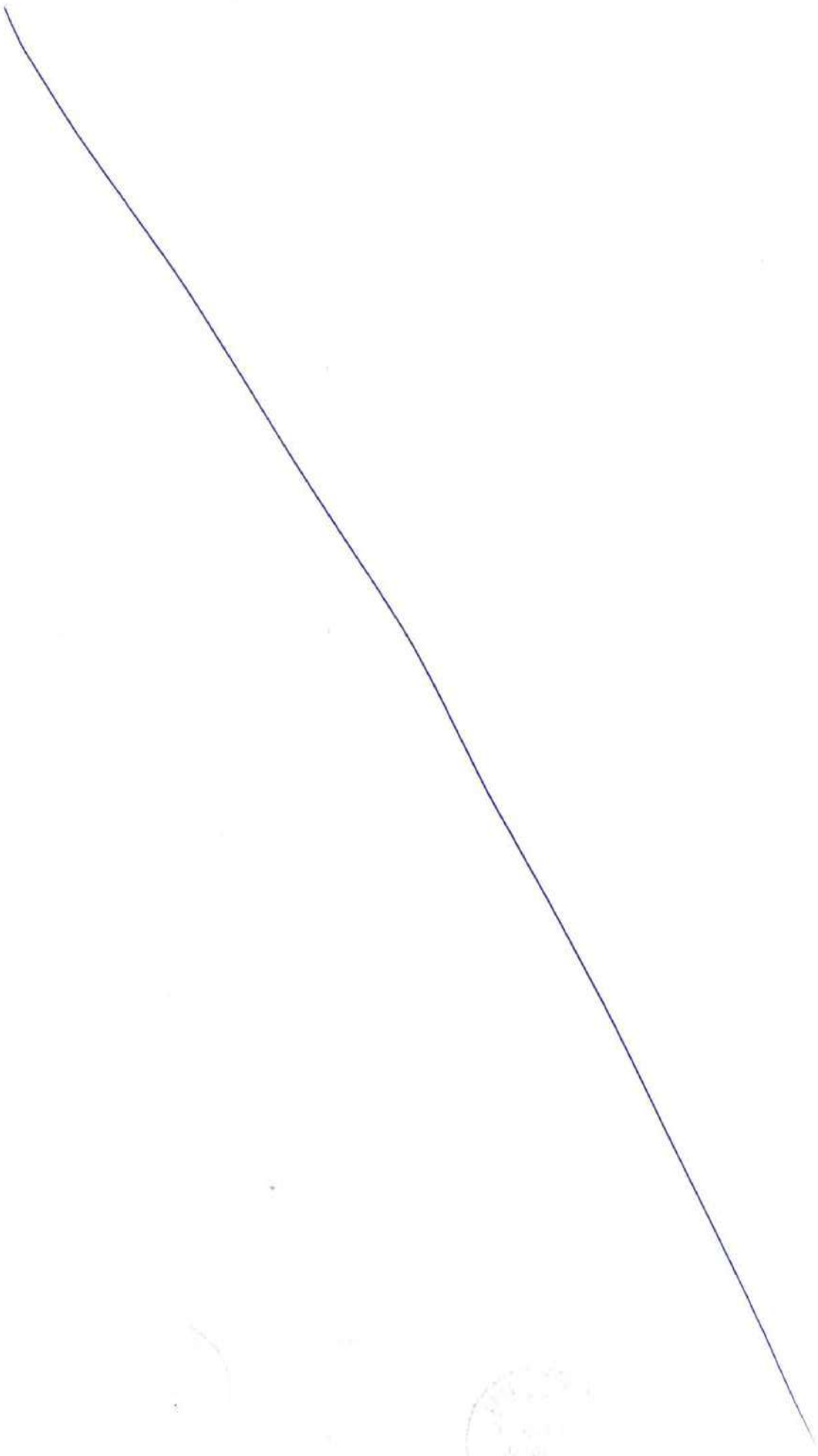
Figure 5-3 Examples of live load combinations for carriageway width 5 design lanes

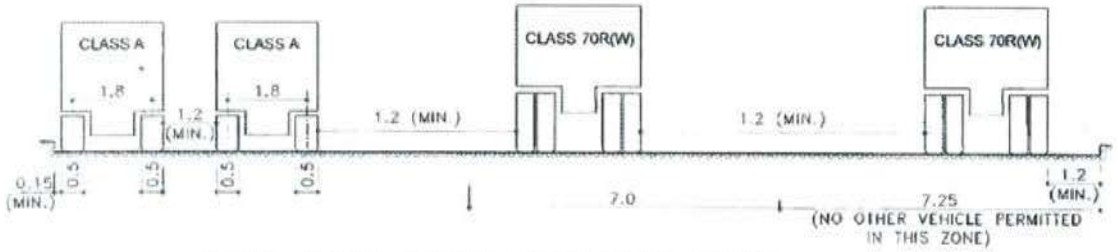


CASE 1 : CLASS A - 6 LANES

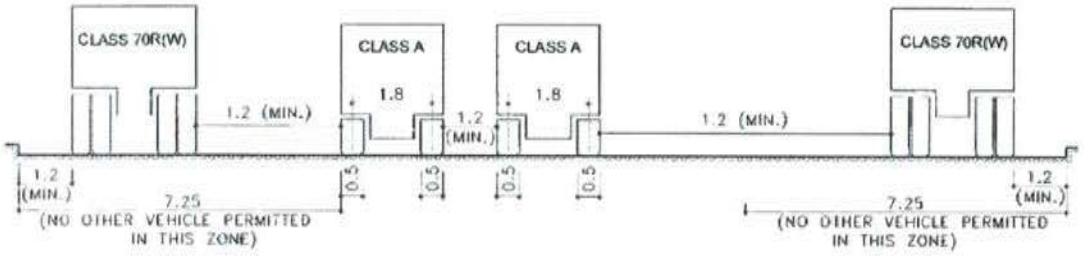


CASE 2 : CLASS A - 4 LANES + CLASS 70R (W)



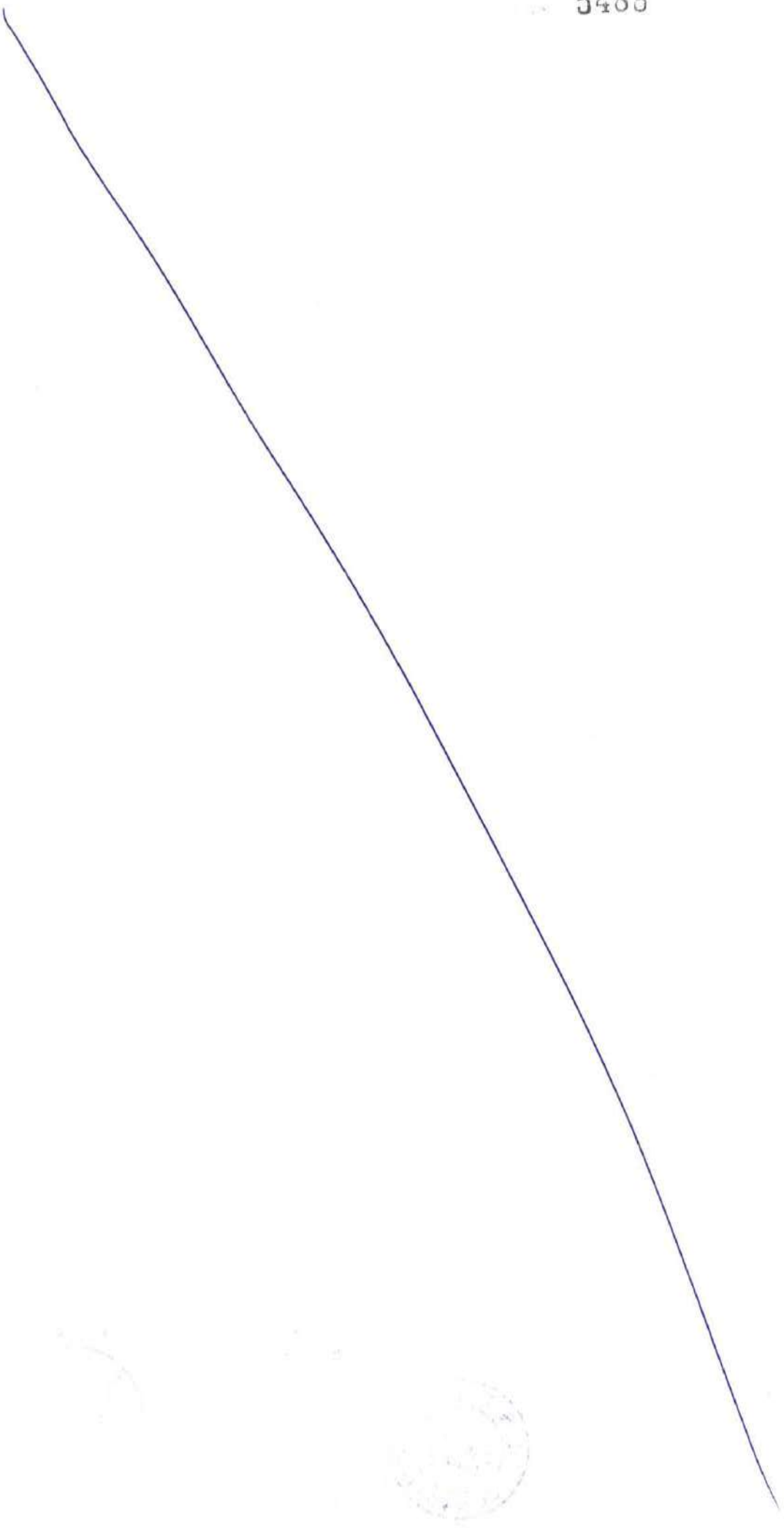


CASE 3 : CLASS A - 2- LANES + CLASS 70R (W) - 2 LANES



CASE 4 : CLASS 70R (W) + CLASS A - 2 LANES + CLASS 70R (W)

Figure 5-4 Examples of live load combinations for carriageway width 6 design lanes

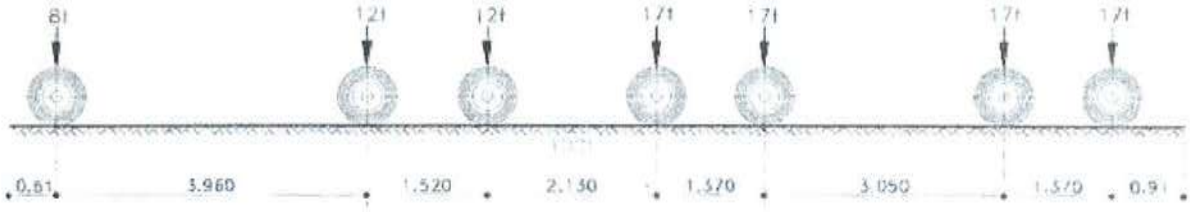


Class 70R live load

Class 70R live loading may be either a wheeled vehicle or a tracked vehicle.

Class 70R Wheeled vehicle

The axle loads and longitudinal arrangement of the Class 70R Wheeled vehicle are shown in Figure 5-5. The total weight of the vehicle is 100 tons. The trailers attached to the driving unit are not considered to be detachable.



CLASS 70R (WHEELED) - LONGITUDINAL POSITION

Figure 5-5 Class 70R Wheeled vehicle. Axle loads and longitudinal arrangement (dimensions in m).

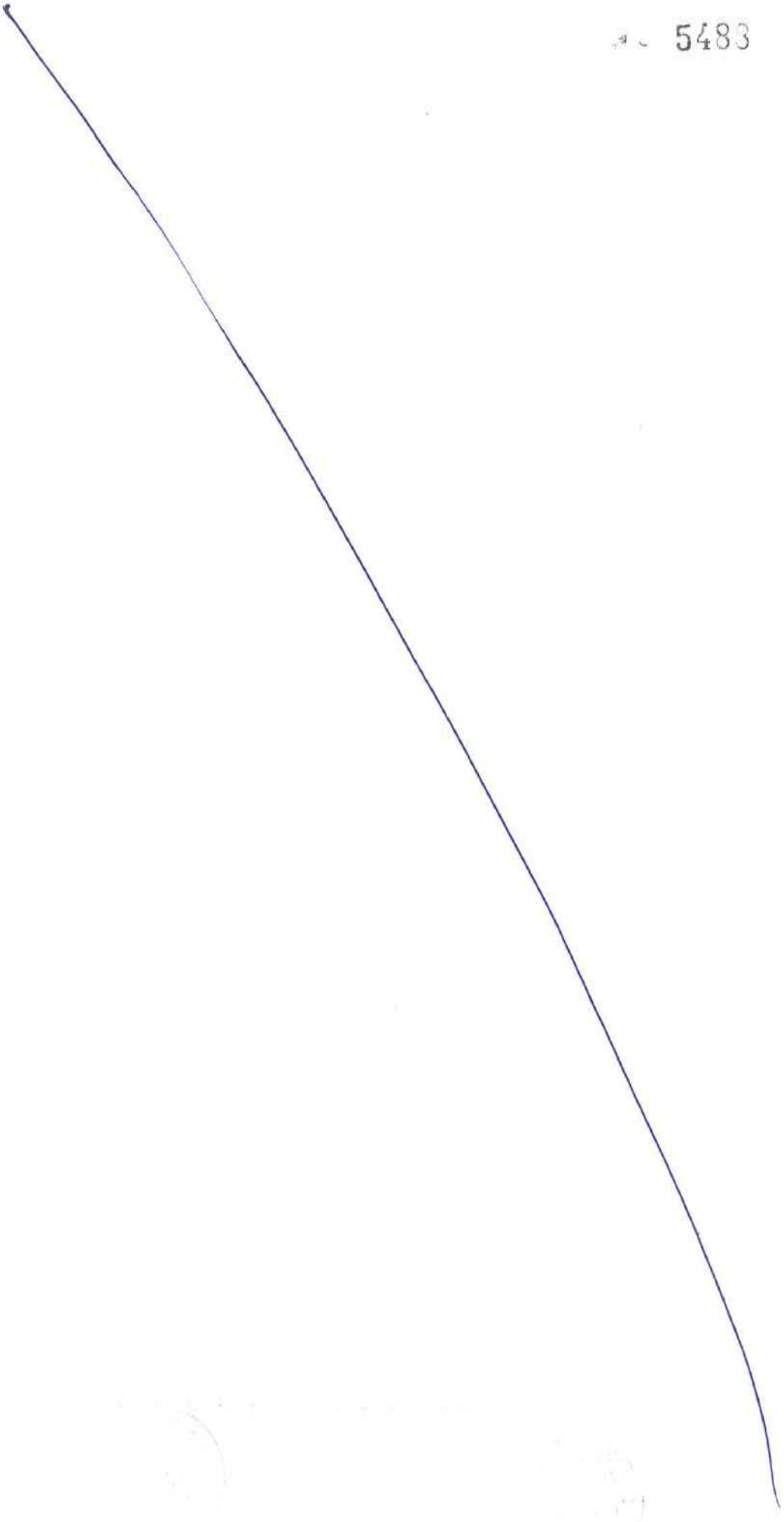
Maximum loads for the Class 70R Wheeled vehicle (for local analyses) shall be 20 tonnes for a single axle and 40 tonnes for a bogie of two axles spaced not more than 1.22 m apart (c/c), see Figure 5-6.

MAX. SINGLE AXLE LOAD

MAX. BOGIE LOAD

Figure 5-6 Class 70R Wheeled vehicle. Axle and bogie loading (dimensions in m).

Minimum wheel spacing and tyre size of critical (heaviest) axles shall be as shown in Figure 5-7.



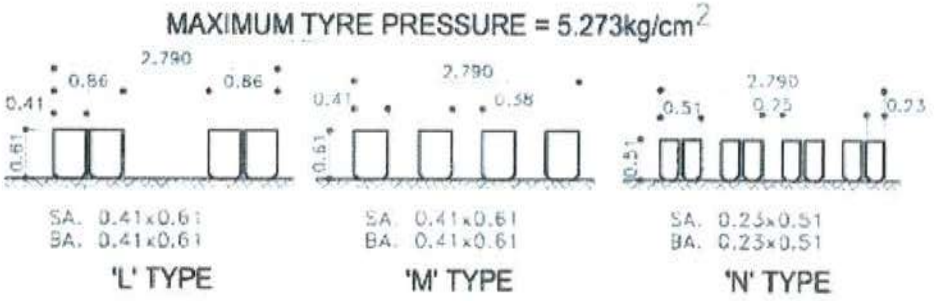


Figure 5-7 Minimum wheel spacing and tyre size of critical (heaviest) axle

In accordance with IRC:6-2017, Annex A, Notes 2 and 3, contact areas of tyres on the deck may be obtained from the corresponding tyre loads, maximum tyre pressures and widths of tyre tread. In Figure 5-7 the first dimension of tyre size refers to the overall width of tyre and second dimension to the rim diameter of the tyre. Tyre tread width may be taken as overall tyre width minus 25 mm for tyres up to 225 mm width, and minus 50 mm for tyres over 225 mm width.

Class 70R Tracked vehicle

The loads, longitudinal arrangement and transverse arrangement of the Class 70R Tracked vehicle are shown in Figure 5-8. The total weight of the vehicle is 70 tons applied along a length of 4.57m.

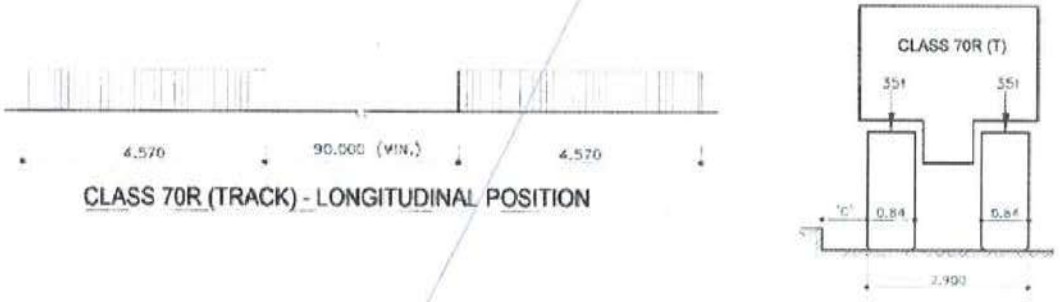
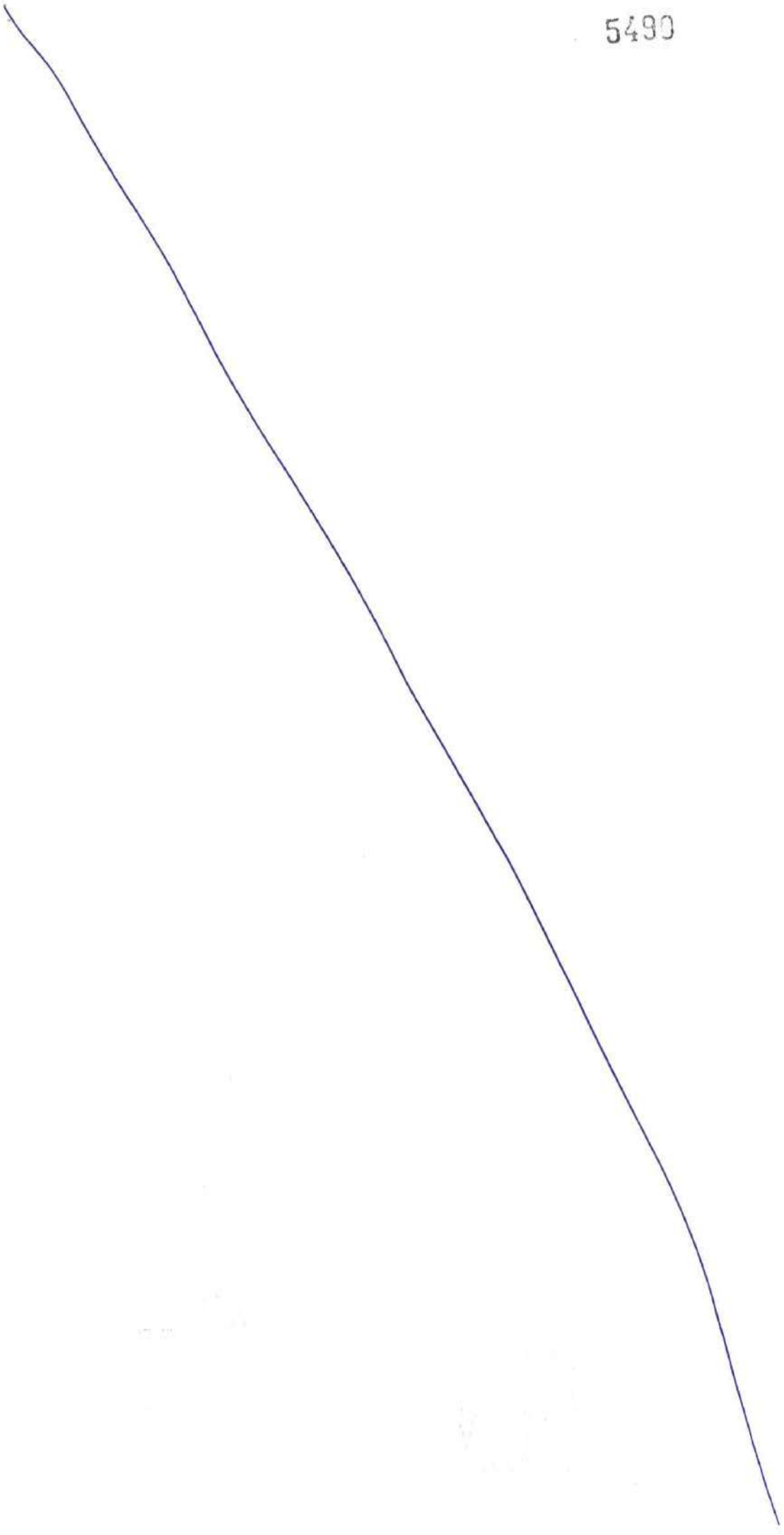


Figure 5-8 Class 70R Tracked vehicle. Axle loads and longitudinal arrangement (dimensions in m).



Application of Class 70R loading

The nose to tail spacing between two successive vehicles shall not be less than 30 m for the wheeled vehicle and 90 m for the tracked vehicle.

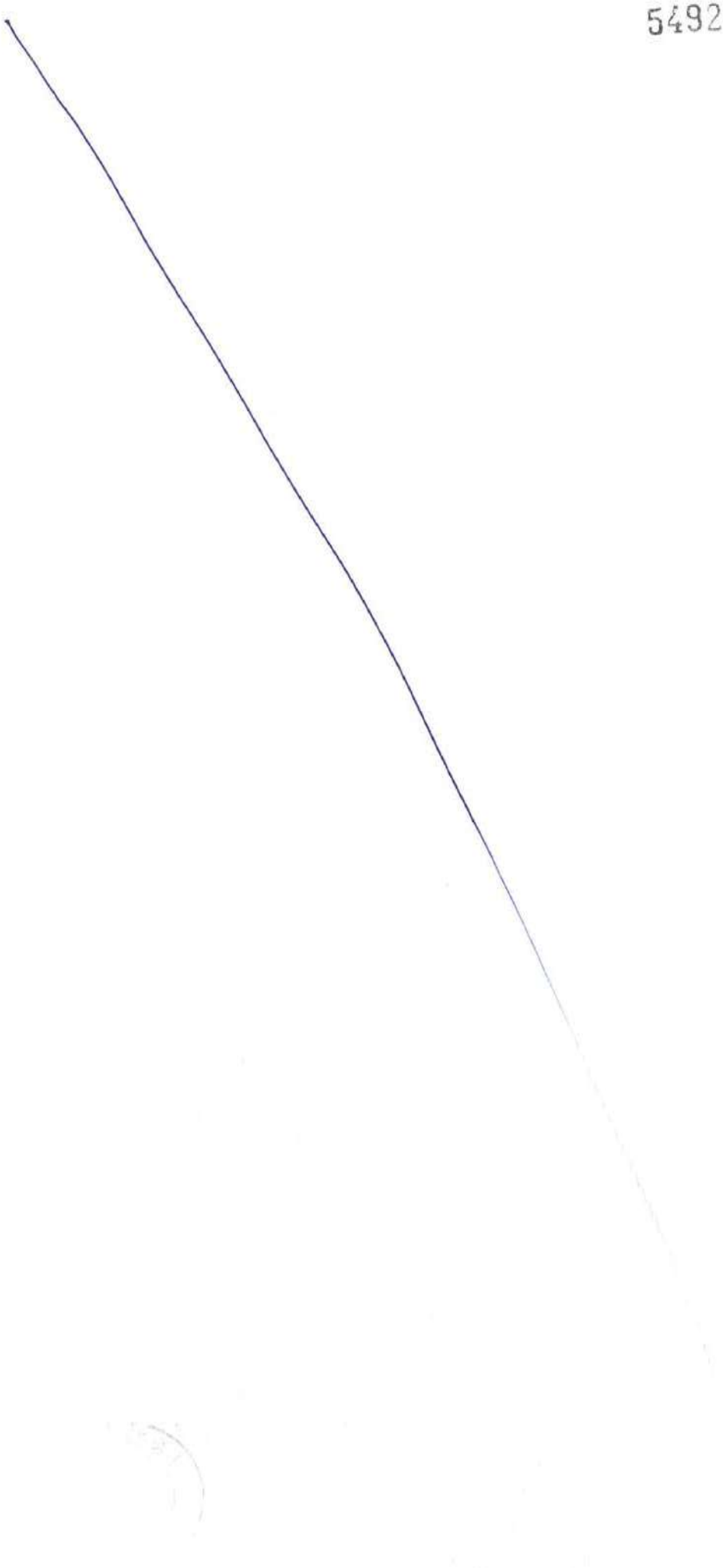
Each Class 70R loading shall be considered to occupy two lanes and no other vehicle shall be allowed in these two lanes. The passing vehicle can only be allowed on lanes other than these two lanes (see Figure 5-2).

The minimum clearance (C) between road face of the kerb and the outer edge of the wheel or track shall be 1.2m.

The minimum clearance between the outer edge of wheel or track of passing or crossing vehicles for multilane bridge shall be 1.2 m. Vehicles passing or crossing can be either same class or different class, tracked or wheeled.

Class A Wheeled vehicle live load

The axle loads and longitudinal arrangement of the Class A Wheeled vehicle are shown in Figure 5-9. The total weight of the vehicle is 55.4 tons. The trailers attached to the driving unit are not considered to be detachable.



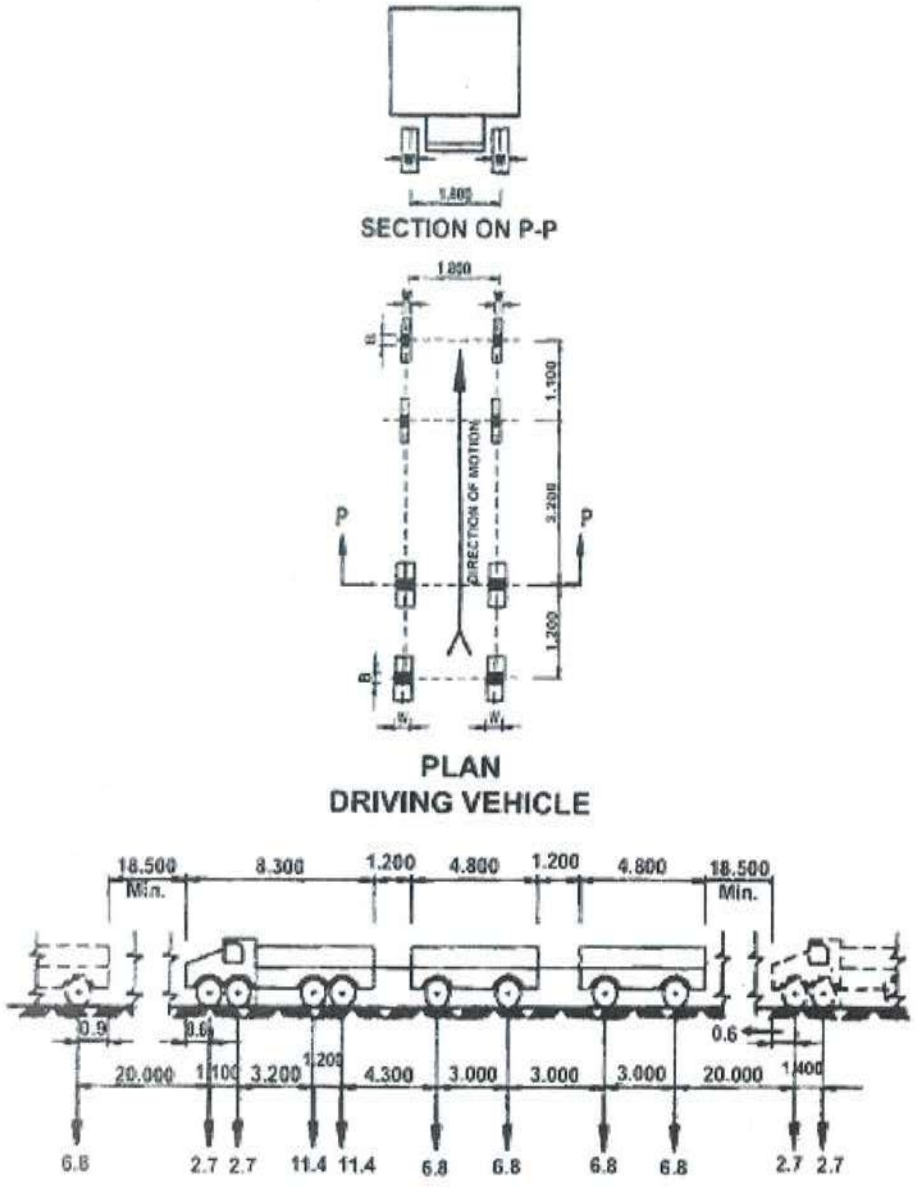
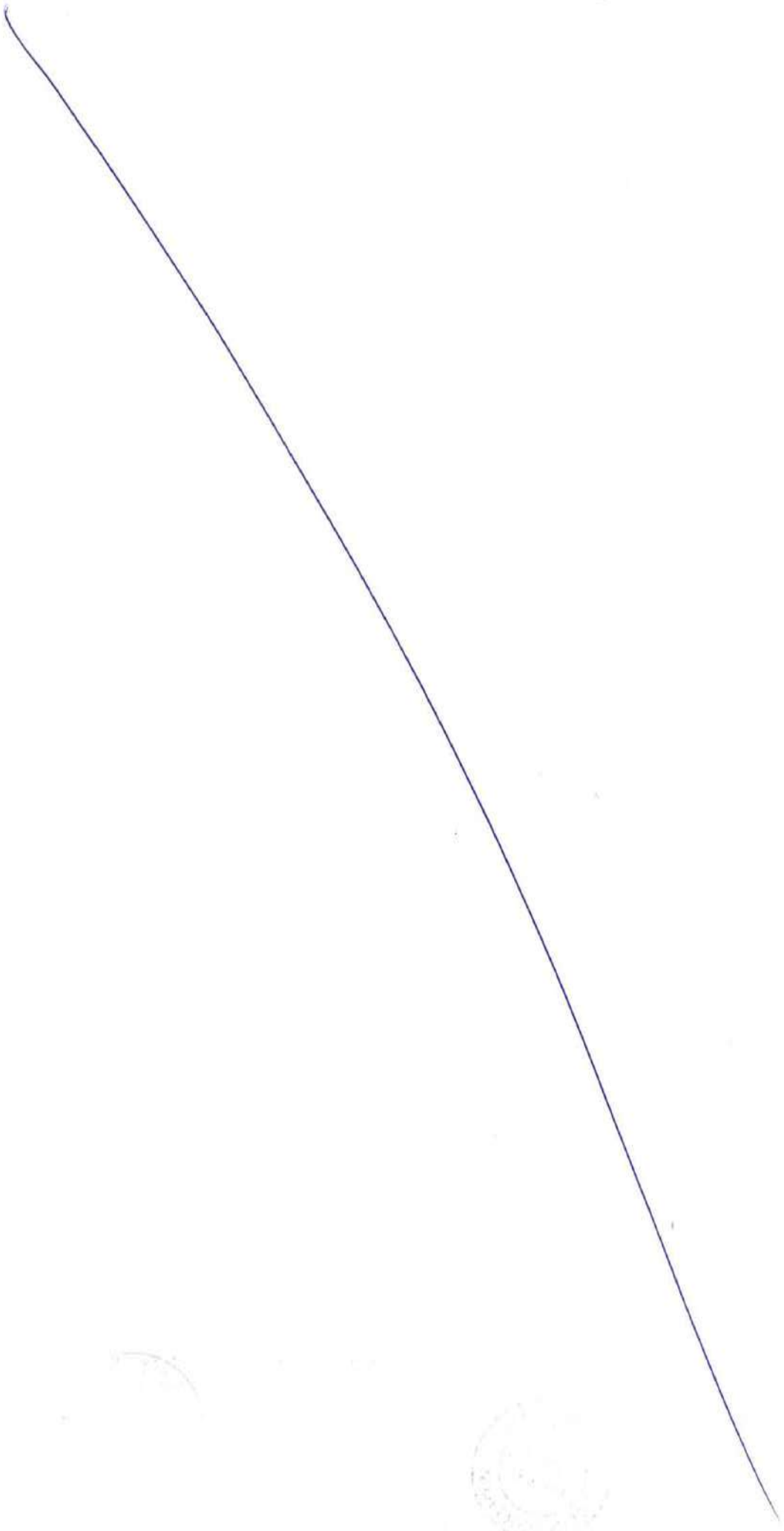


Figure 5-9 Class A Live Load. Axle loads and longitudinal arrangement (dimensions in m).

The contact areas for the wheels of Class A loading shall be as in Table 5-6.

Table 5-6 Ground contact areas for wheels of Class A loading



Axle Load (tonnes)	B (mm)	W (mm)
11.4	250	500
6.5	200	380
2.7	150	200

Application of Class A loading

The nose to tail spacing of two successive vehicles shall not be less than 18.5m. For multi-lane bridges each Class A loading shall be considered to occupy single lane for design purposes. The minimum distance between the outer edge of the wheel and the roadway face of the kerb shall be 1.5 m. The minimum distance between the outer edge of the wheels of two passing vehicles shall be 1.2 m.

Special Vehicle (SV) live load

The axle loads and longitudinal arrangement of the Special Vehicle (SV) live load are shown in Figure 5-10. The total weight of the vehicle is 385 tonnes. The transverse wheel spacing and wheel contact area shall be as shown in Figure 5-11.

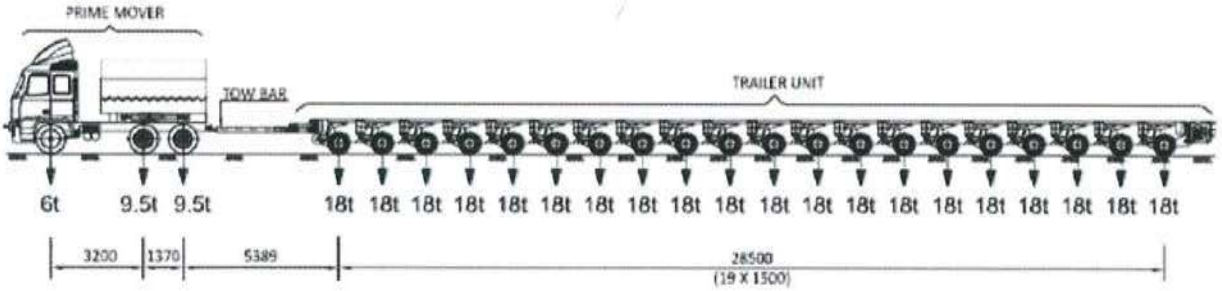
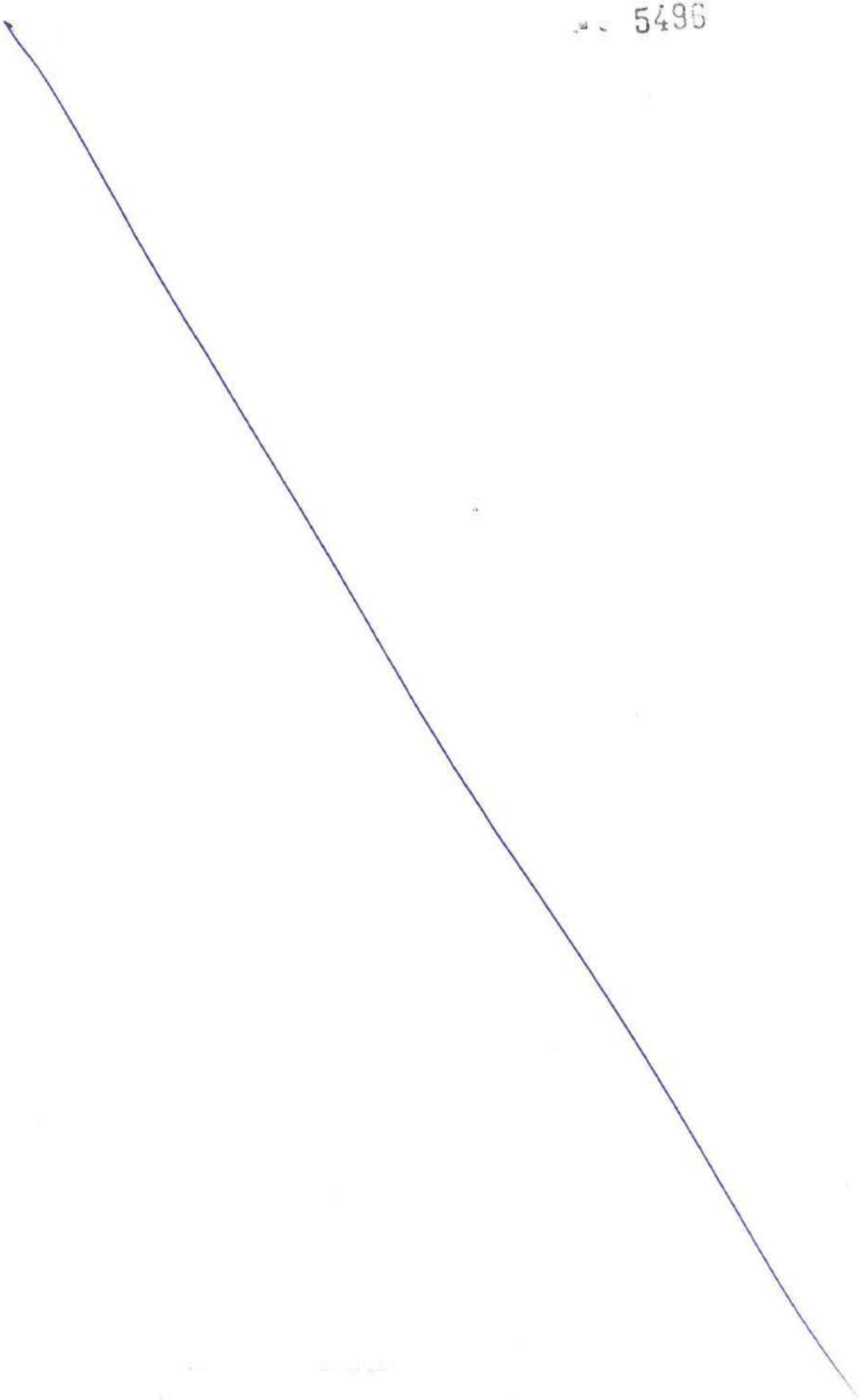


Figure 5-10 Special Vehicle (SV) live load – Axle loads and longitudinal arrangement (dimensions in mm)



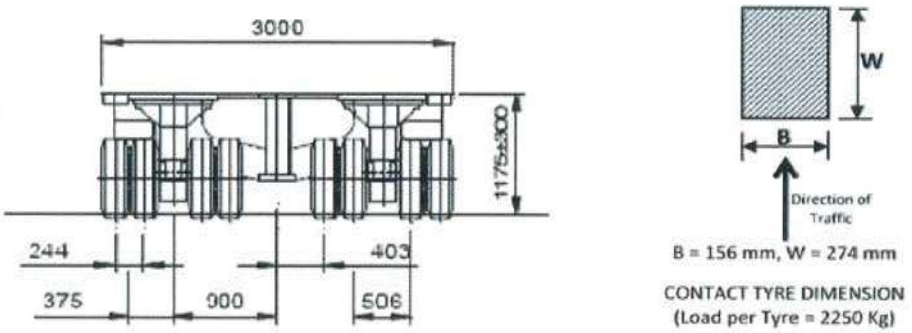


Figure 5-11 Special Vehicle (SV) live load – Transverse wheel spacing and wheel contact area (dimensions in mm)

Application of Special Vehicle (SV) loading

Special Vehicle loading shall be considered to run close to the centre of the carriageway, with a maximum eccentricity of 300 mm from the centre of the carriageway, as shown in Figure 5-12.

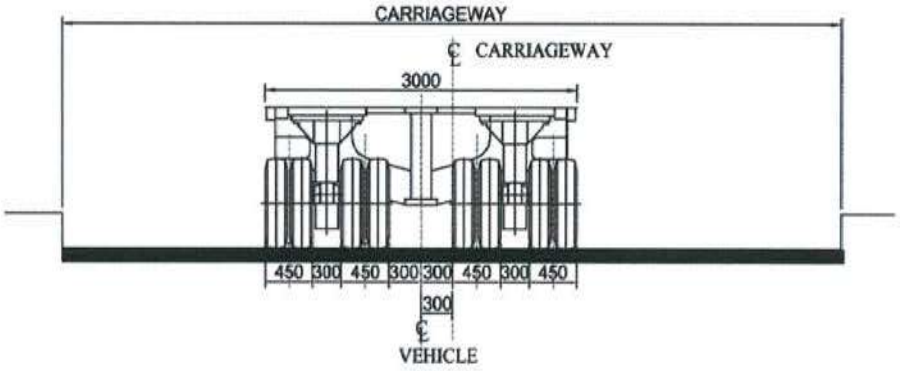
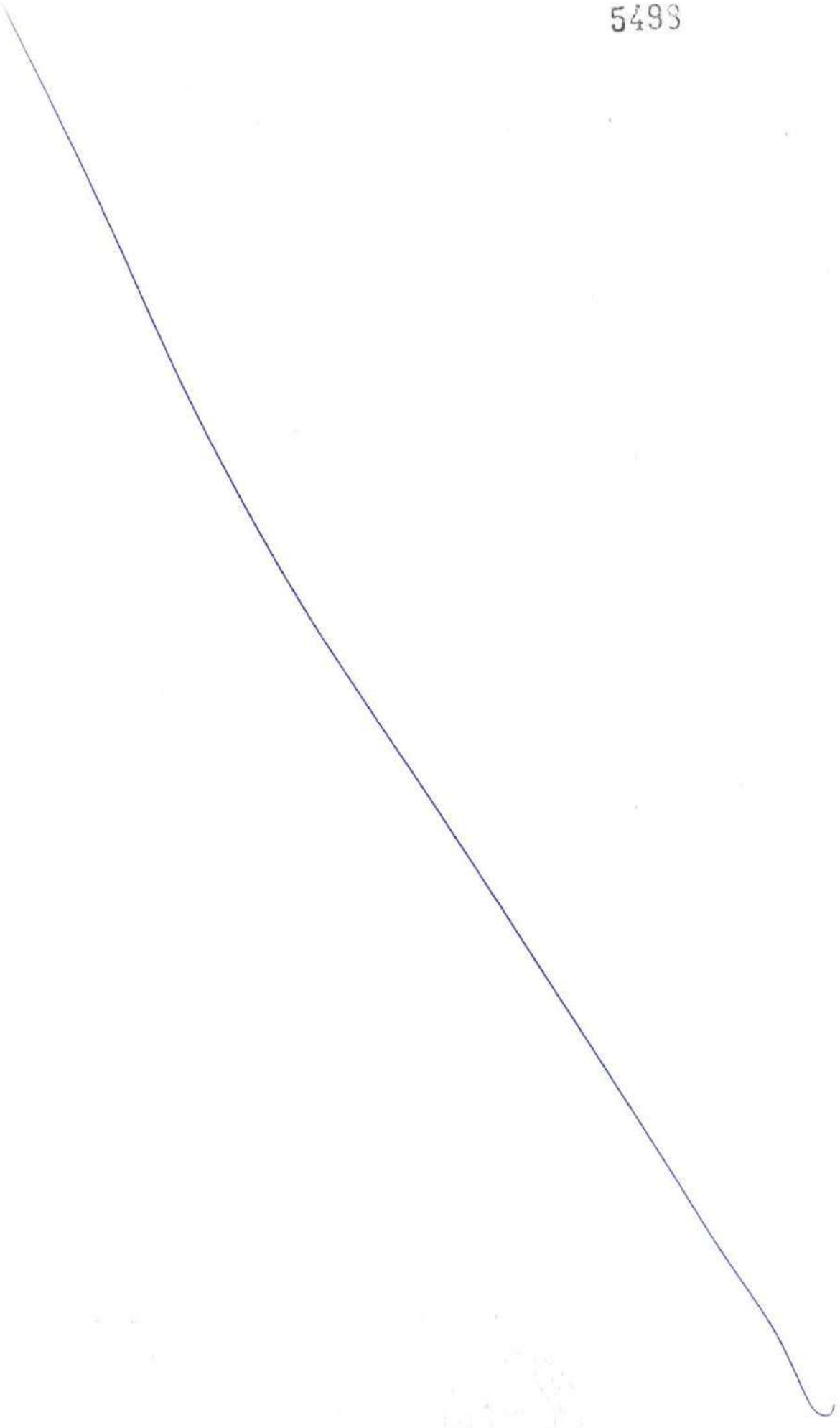


Figure 5-12 Limit of transverse location of SV load on carriageway (dimensions in mm)

During the passage of the Special Vehicle, no other vehicles shall be considered to be present on the bridge.

Wind load, seismic load, congestion factor, impact factor, braking force and reduction factor shall not be considered with Special Vehicle loading.

The Special Vehicle shall not be considered to move faster than 5 km/h.



Congestion Factor

Congestion shall be considered in accordance with IRC:6-2017, §204.4. The congestion factor shall be considered as a multiplying factor on the global effect of vehicular live load only (including impact). Under this condition, horizontal force due to braking/ acceleration, centrifugal action and temperature effect and effect of transverse eccentricity of live load shall not be included.

Table 5-7 Congestion factor

Span Range	Congestion Factor
Above 10.0 m and up to 30.0 m	1.15
30.0 m to 40.0 m [1]	1.15 to 1.30
40.0 m to 50.0 m [1]	1.30 to 1.45
50.0 m to 60.0 m [1]	1.45 to 1.60
60.0 m to 70.0 m [1]	1.60 to 1.70
Above 70.0 m	1.70
Note 1. Obtain factor for intermediate span lengths by interpolation	

Congestion factor shall not be considered for Special Vehicle (SV) live load.

Impact Factor (Q_{im})

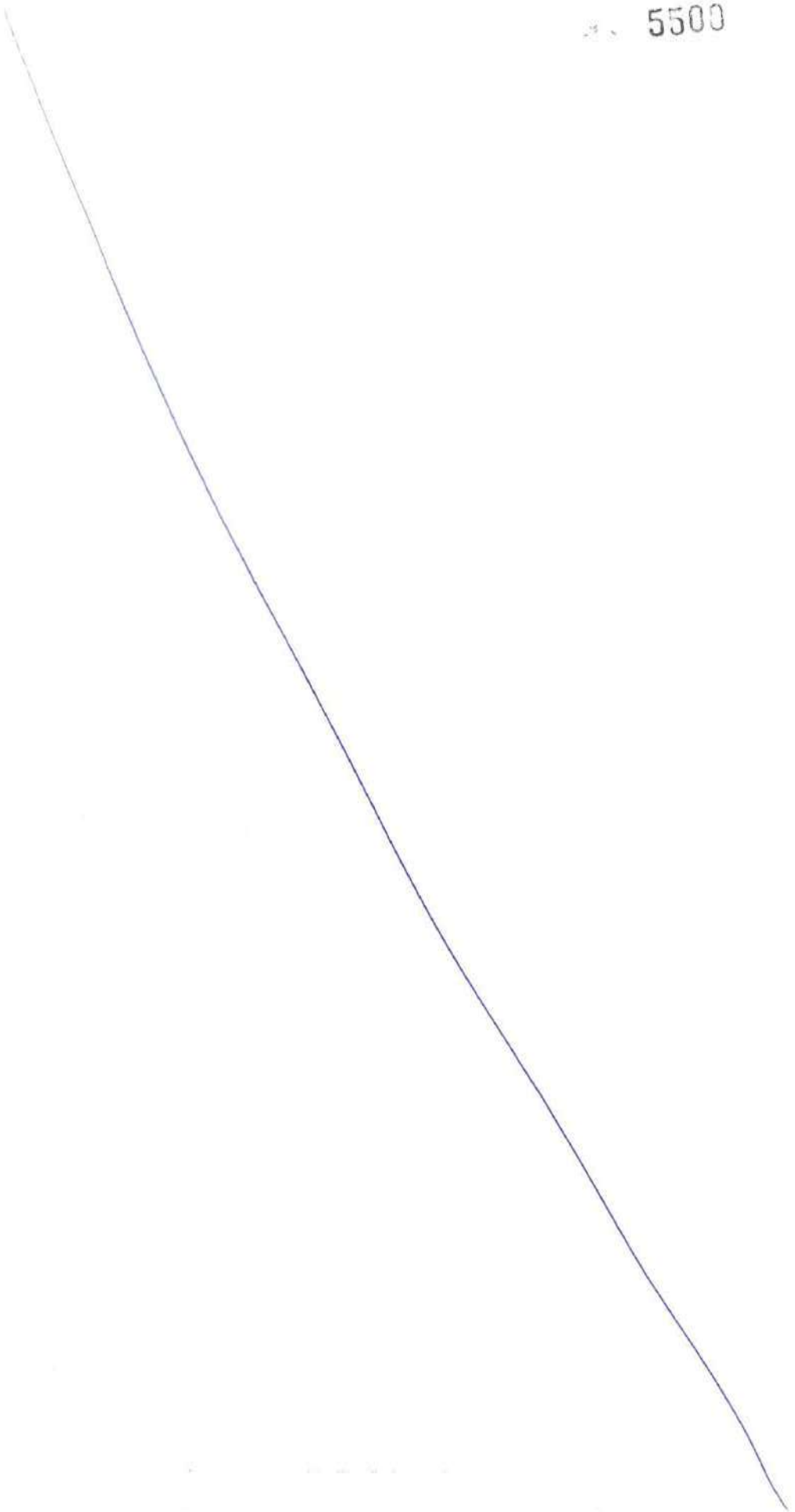
Provision for impact or dynamic action for live load shall be made by an increment of the live load by an impact allowance in accordance with IRC:6-2017, §208.

Class A loading

Impact percentages shall be in accordance with Table 5-8, which summarises IRC:6-2017, §208.2.

Table 5-8 Impact percentage for Class A loading (L = span length in m)

Bridge Type	Span Range		
	0 – 3 m	3 – 45 m	> 45 m
Reinforced concrete	50%	[4.5/(6 + L)] x 100%	8.8%



Steel	54.5%	[9/(13.5 + L)] x 100%	15.4%

Class 70R loading

Impact percentages shall be in accordance with Table 5-10 and Table 5-11, which summarises IRC:6-2017, §208.3.

Table 5-9 Impact percentage for Class 70R Wheeled vehicle (L = span length in m)

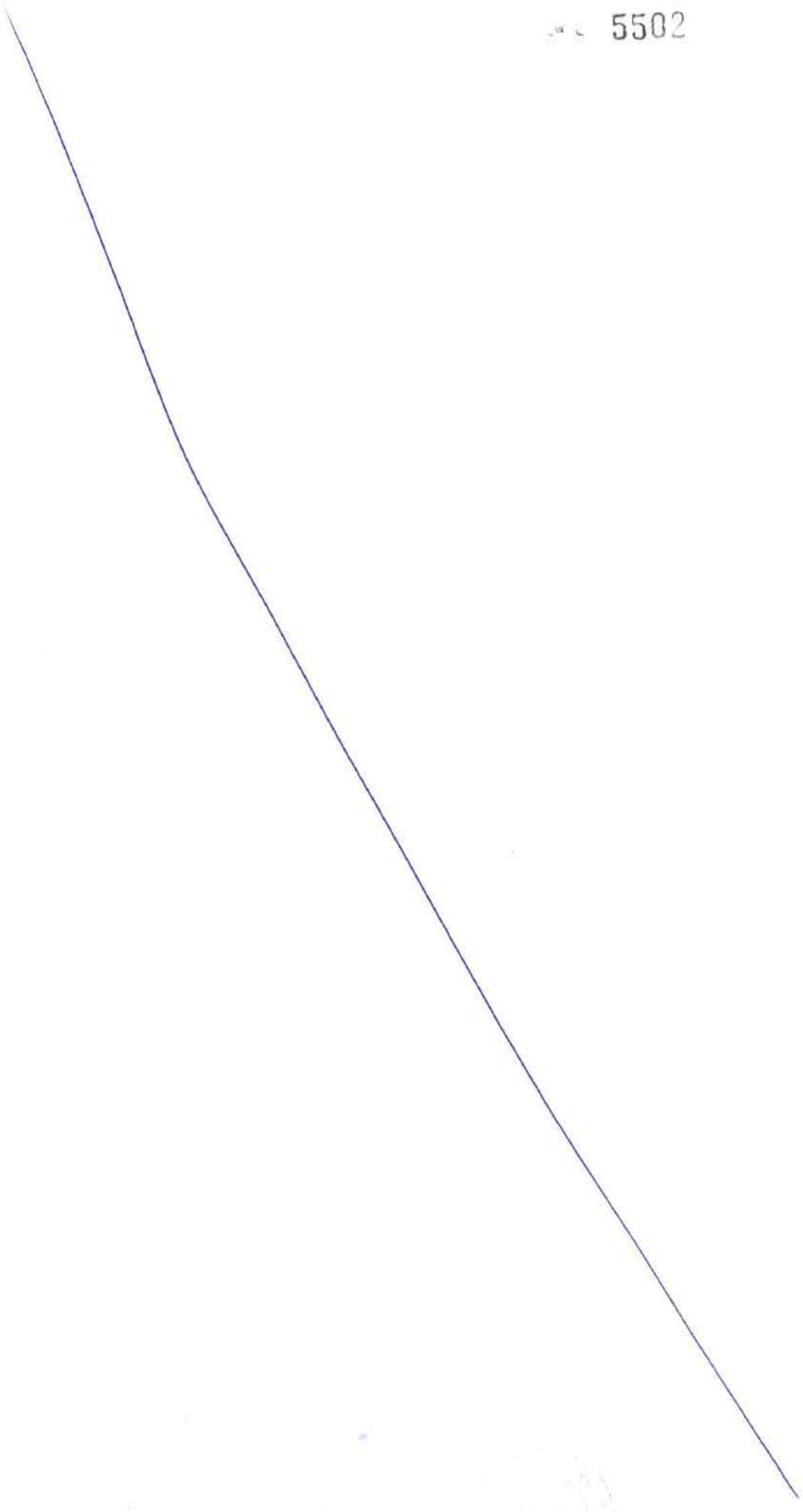
Bridge Type	Span Range			
	0 – 12 m	12 – 23 m	23 - 45 m	> 45 m
Reinforced concrete	25%	[4.5/(6 + L)] x 100 %		8.8%
Steel		25%	[9/(13.5 + L)] x 100%	15.4%

Table 5-10 Impact percentage for Class 70R Tracked vehicle (L = span length in m)

Bridge Type	Span Range				
	0 – 5 m	5 - 9 m	9 – 40 m	40 - 45 m	> 45 m
Reinforced concrete	25%	25 – (L - 5) x 3.75 %	10%	[4.5/(6 + L)] x 100%	8.8%
Steel			10%		

Special Vehicle (SV) loading

Impact factor shall not be considered.



Horizontal traffic loads

Longitudinal traffic actions (F_a, F_b & F_f)

Longitudinal traffic actions shall be determined in accordance with IRC:6-2017, §211. Horizontal traffic actions shall not be considered for Special Vehicle (SV) loading.

Braking

Longitudinal braking forces shall be calculated as follows:

- For bridges with two lanes
  - Fb = 20% first train load
    + 10% succeeding train loads (or part thereof)
  - Only the train loads in one lane are to be considered.
- For bridges with more than two lanes

  Fb = Braking force for bridge with two lanes (see above)
  + 5% of loads in the third and subsequent lanes

Increase in loads due to impact shall not be applied for the calculation of braking forces.

Braking forces shall be assumed to act along a line parallel to the roadway and 1.2 m above it.

Tractive Effort

In accordance with IRS:6-2014, §211.1, NOTE, braking forces are considered to be greater than forces from tractive effort.

Reduction Factor

Reduction in longitudinal load effects in bridges having more than two traffic lanes dues to the low probability that all lanes will be subject to the full characteristic loads simultaneously shall be applied in accordance with IRC:6-2017, §205, as follows.

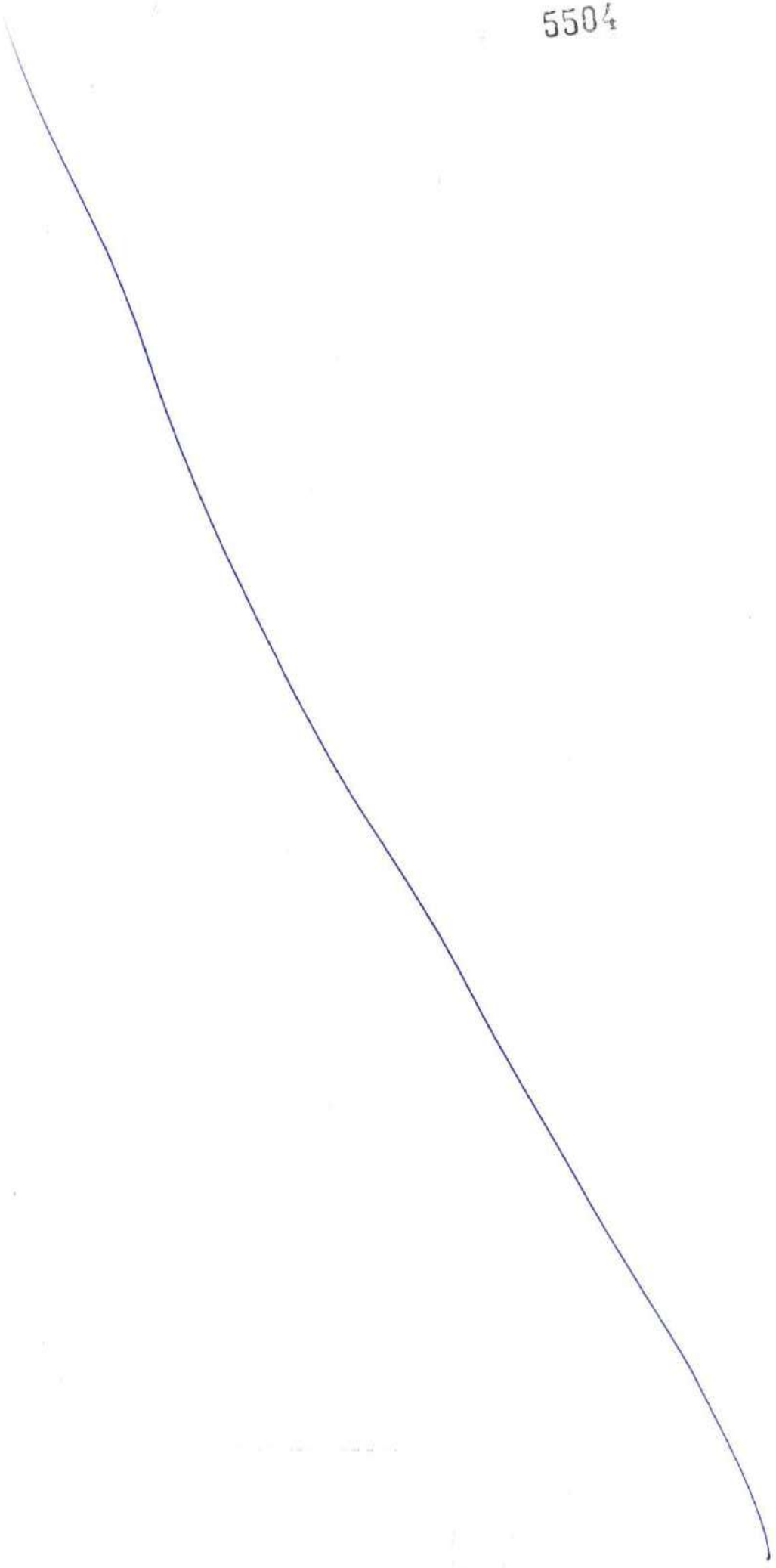


Table 5-11 Reduction Factor

Number of lanes occupied	Reduction
2	No reduction
3	10 %
4 - 10	20 %

Centrifugal force (F_{ct})

Centrifugal forces shall be determined in accordance with IRC:6-2017, §212.

Pedestrian/footway load

There are no pedestrian footways on the main bridges or ramps.

5.3 ENVIRONMENTAL LOADS

Wind (W)

Wind loads shall be determined in accordance with IRC:6-2017, §209, unless stated otherwise in this document.

Basic wind speed

The basic wind speed for Mumbai, taken from IRC:6-2017, Figure 10, is 44 m/s.

Hourly mean wind speed and wind pressure

The hourly mean wind speed and wind pressure for a basic wind speed of 44 m/s are given in Table 5-12, for a bridge situated in plain terrain.

Table 5-12 Hourly mean wind speed and wind pressure for a basic wind speed = 44 m/s, for bridge situated in plain terrain

Average height of surface above ground/water, H (m)	Hourly mean wind speed, V_z [1] (m/s)	Horizontal Wind Pressure, P_z [2] (N/m^2)

Up to 10m	37.1	825
15	39.0	912
20	40.4	979
30	41.9	1050
50	44.2	1172
60	44.8	1202

Notes 1. Values obtained by multiplying corresponding value in IRC:6-2017, Table 12 by the ratio of basic wind speed of the bridge site to the basic wind speed corresponding to Table 5 (33 m/s) (i.e. factor by 44/33 = 1.333).

2. Values obtained by multiplying corresponding value in IRC:6-2017, Table 12 by the ratio of square of basic wind speed of the bridge site to the square of the basic wind speed corresponding to Table 5 (33 m/s) (i.e. factor by $44^2/33^2 = 1.778$).

Design wind force on bridge deck

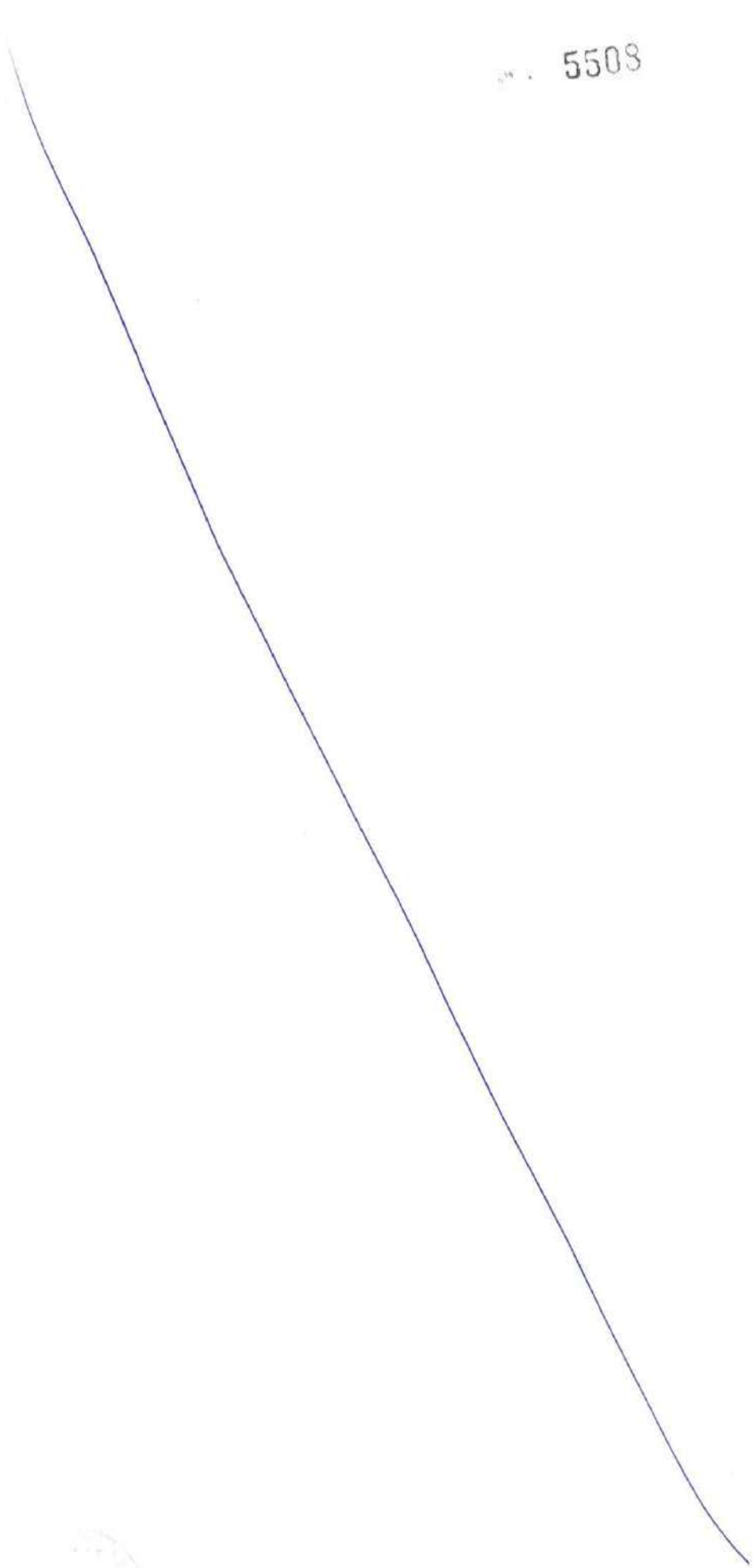
The design wind force on the bridge superstructure (deck) shall be determined in accordance with IRC:6-2017, §209.3.

Drag coefficients for the twin box girder bridges of MTHL shall be determined in accordance with EN 1991-1-4, §8.3.1, as this code includes specific provision for considering the drag coefficient for two separate, similar bridge decks, at the same level and separated by a gap less than 1.0m (not specifically covered by IRC:6-2017).

For Tender Design of the twin box girder bridge decks, drag coefficients, C_D , in accordance with Table 5-13 shall be used.

Table 5-13 Drag coefficient on bridge superstructure (deck) for Tender Design

Width/Depth Ratio [1, 2]	C_D
W/D ≤ 0.33	2.4
0.33 < W/D ≤ 5	$2.4 < C_D \leq 1.0$ [3]



W/D > 5	1.0

Notes
1. W = Overall width of bridge deck. Where the gap between two adjacent bridge decks is less than 1.0 m, take W = combined width of bridge decks.
2. D = Overall depth of bridge deck. Where relevant, D shall include the height of traffic or noise/view/safety barriers.
3. Obtain intermediate values by linear interpolation.

[Note. For detailed design, drag coefficients for steel bridge decks shall be determined by wind tunnel tests.]

For other bridge decks, drag factors shall be determined in accordance with

Design wind force on bridge piers

The design wind force on the bridge substructure (piers) shall be determined in accordance with IRC:6-2017, §209.4.

For Tender Design, a drag coefficient of C_D = 2.0 shall be used.

Coexistent wind and traffic load

Bridges shall not be considered to carry any live load (traffic) when the gust wind speed at deck level exceeds 36 m/s (ref. IRC:6-2017, §209.3.7). Drag coefficients shall be determined in accordance with EN 1991-1-4, §8.3.1, taking into account the traffic present on the bridge.

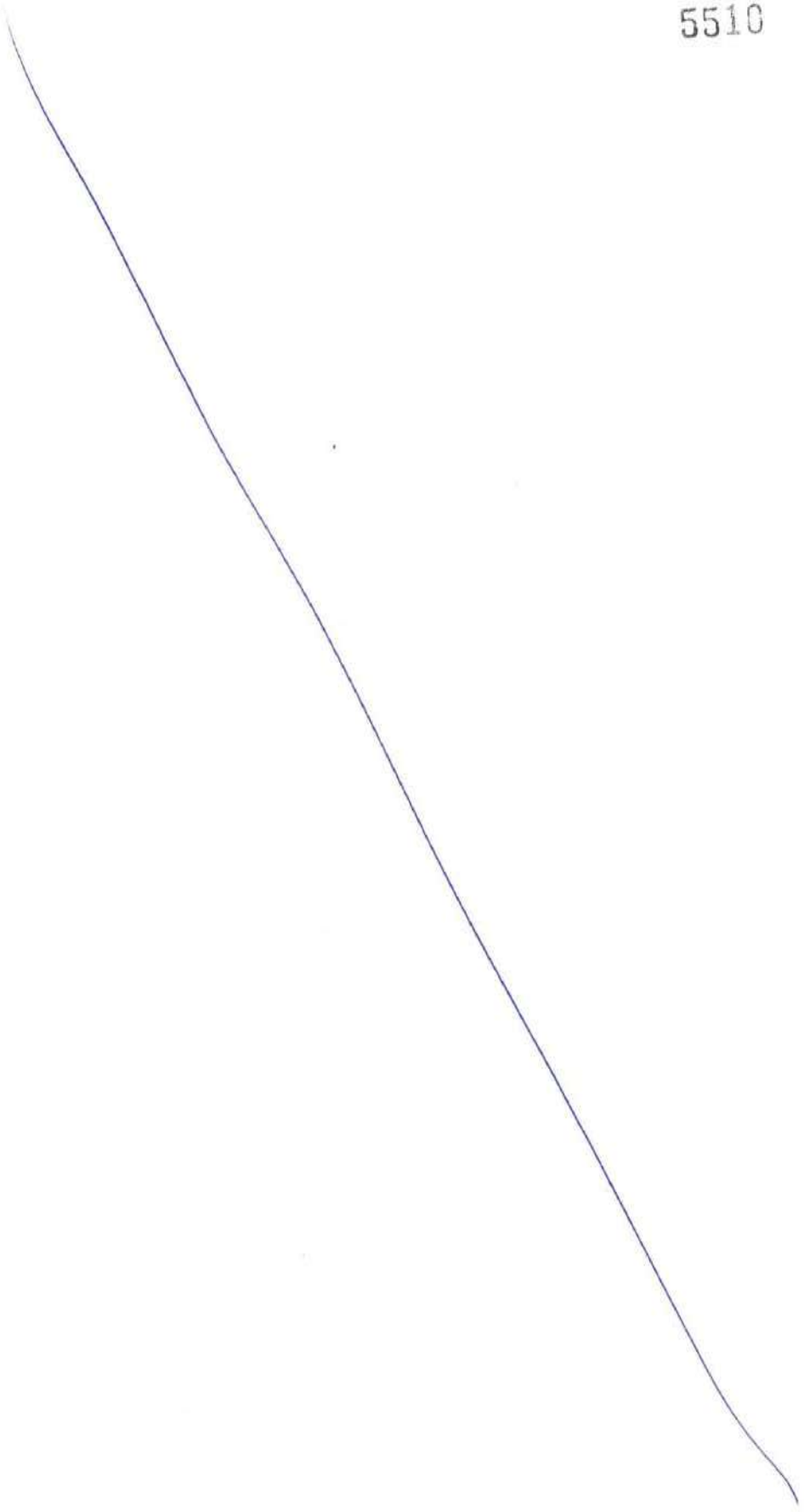
Temperature (T)

Temperature effects shall be determined in accordance with IRC:6-2017, §215, unless stated otherwise in this document.

Air shade temperatures

Maximum and minimum air shade temperatures for Mumbai are obtained from IRC:6-2017, Figure 15 and Figure 16, respectively, as follows:

- Maximum air shade temperature : +42.5 °C
- Minimum air shade temperature : +10 °C



- Mean air shade temperature = (+42.5 + +10)/2 = +26.3 °C

Uniform temperature differences

Uniform temperature differences are calculated in accordance with IRC:6-2017, §215.2, as follows:

- Concrete bridges
  - Temperature Rise

    Reference temperature = +26.3 - 10 = +16.3 °C

    Temperature rise (+) = +42.5 - +16.3 = (+) 26.2 °C
  - Temperature Fall

    Reference temperature = +26.3 + 10 = +36.3 °C

    Temperature fall (-) = +10 - +36.3 = (-) 26.3 °C
- Steel bridges
  - Temperature rise

    Effective bridge temp. = +42.5 + 15 = +57.5 °C

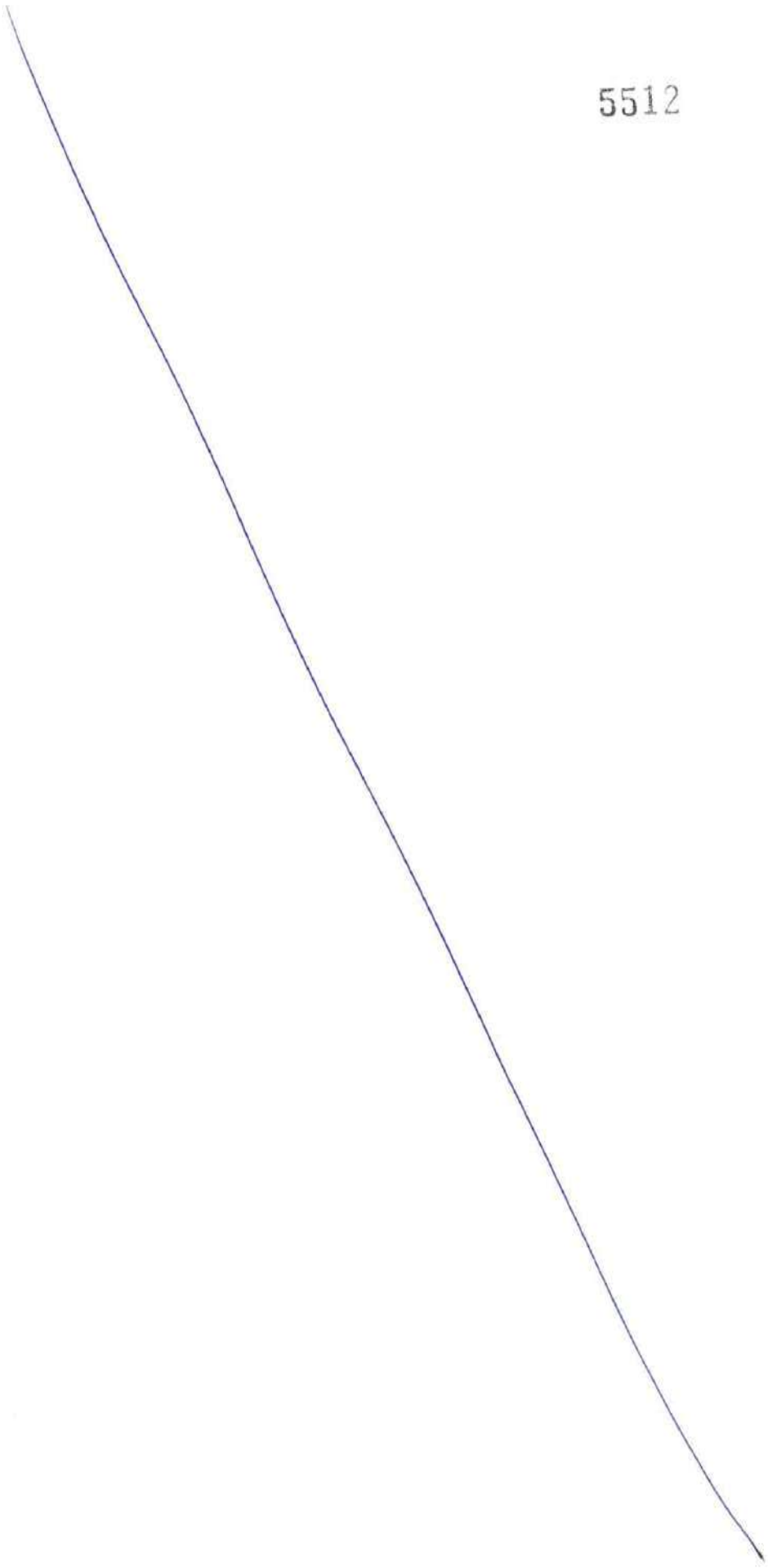
    Temperature rise (+) = +57.5 - +26.3 = (+) 31.2 °C
  - Temperature fall

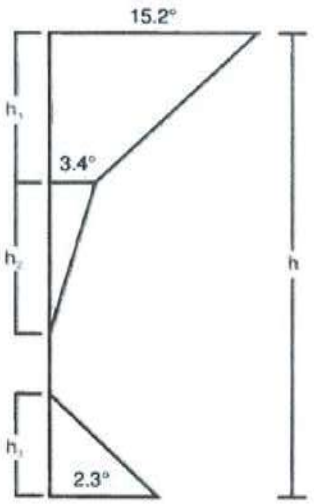
    Effective bridge temp. = +10 - 10 = 0 °C

    Temperature fall (-) = 0 - +26.3 = (-) 26.3 °C

Temperature gradient

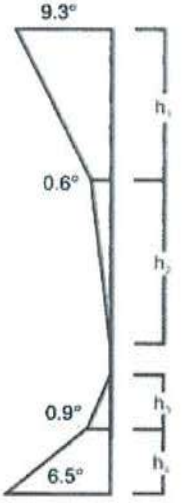
Temperature gradients for concrete bridge decks shall be determined in accordance with Figure 5-13. The temperatures stated in Figure 5-13 are based on those given in IRC:6-2017, Fig.17(a), but adjusted to suit 80 mm thick bridge deck surfacing, in accordance with EN 1991-1-5, Table B.3.





$h_1 = 0.3h < 0.15$ m
$h_2 = 0.3h > 0.10$ m
< 0.25 m
$h_3 = 0.3h < 0.10$ m

(a) Positive temperature gradient

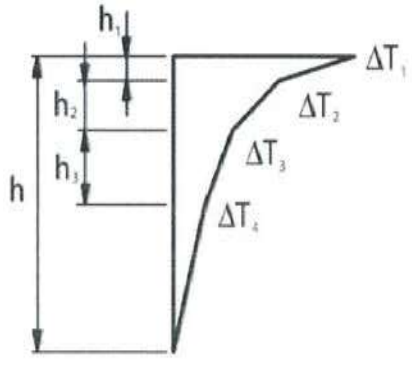


$h_1 = h_4 = 0.2h < 0.25$ m
$h_2 = h_3 = 0.25h < 0.25$ m

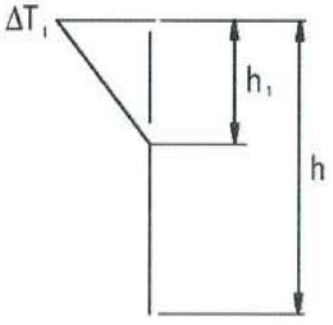
(b) Reverse temperature gradient

Figure 5-13 Temperature gradient for concrete bridge decks

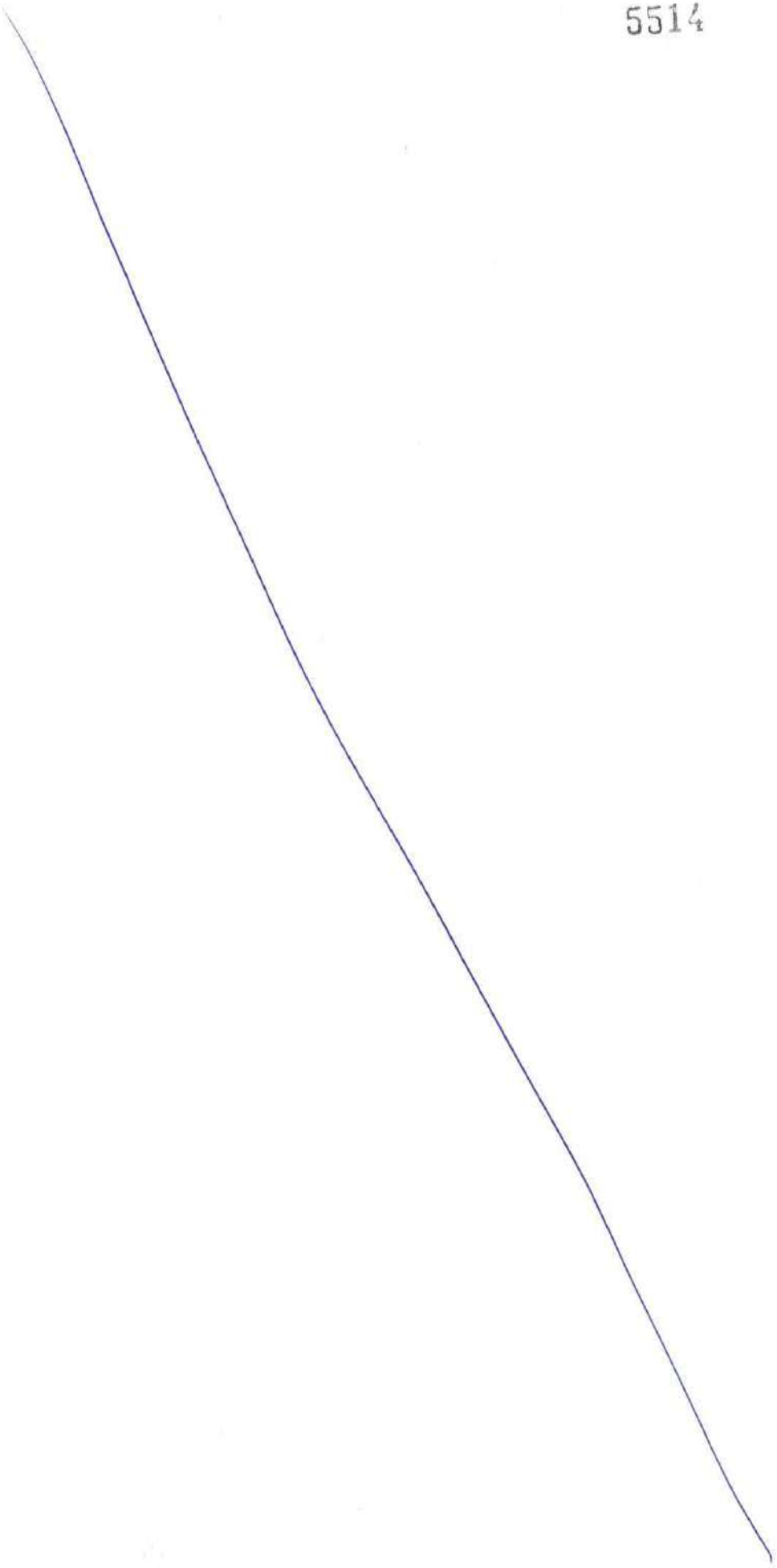
Temperature differences for steel bridges decks, with orthotropic steel deck plates with surfacing, shall be determined in accordance with Figure 5-14 (taken from EN 1991-1-5, Figure 6.2a).



$h_1 = 0.1$ m $\quad \Delta T_1 = 24°C$



$h_1 = 0.5$ m $\quad \Delta T_1 = -6°C$



h_2 = 0.2 m	ΔT_2 = 14°C
h_3 = 0.3 m	ΔT_3 = 8°C
	ΔT_4 = 4°C

(a) Positive temperature gradient

(b) Reverse temperature gradient

Figure 5-14 Temperature gradient for steel bridges with orthotropic steel decks (surfaced)

Coefficient of linear thermal expansion

The coefficients of linear thermal expansion for reinforced concrete, pre-stressed concrete and steel structures shall be taken as 12 x 10^{-6} /°C

Water currents

Horizontal forces due to water currents shall be determined in accordance with IRC:6-2017, §210.

A minimum current speed of 3 m/s in any direction shall be considered in design.

Waves

The effects of normal and abnormal wave loading shall be considered in design.

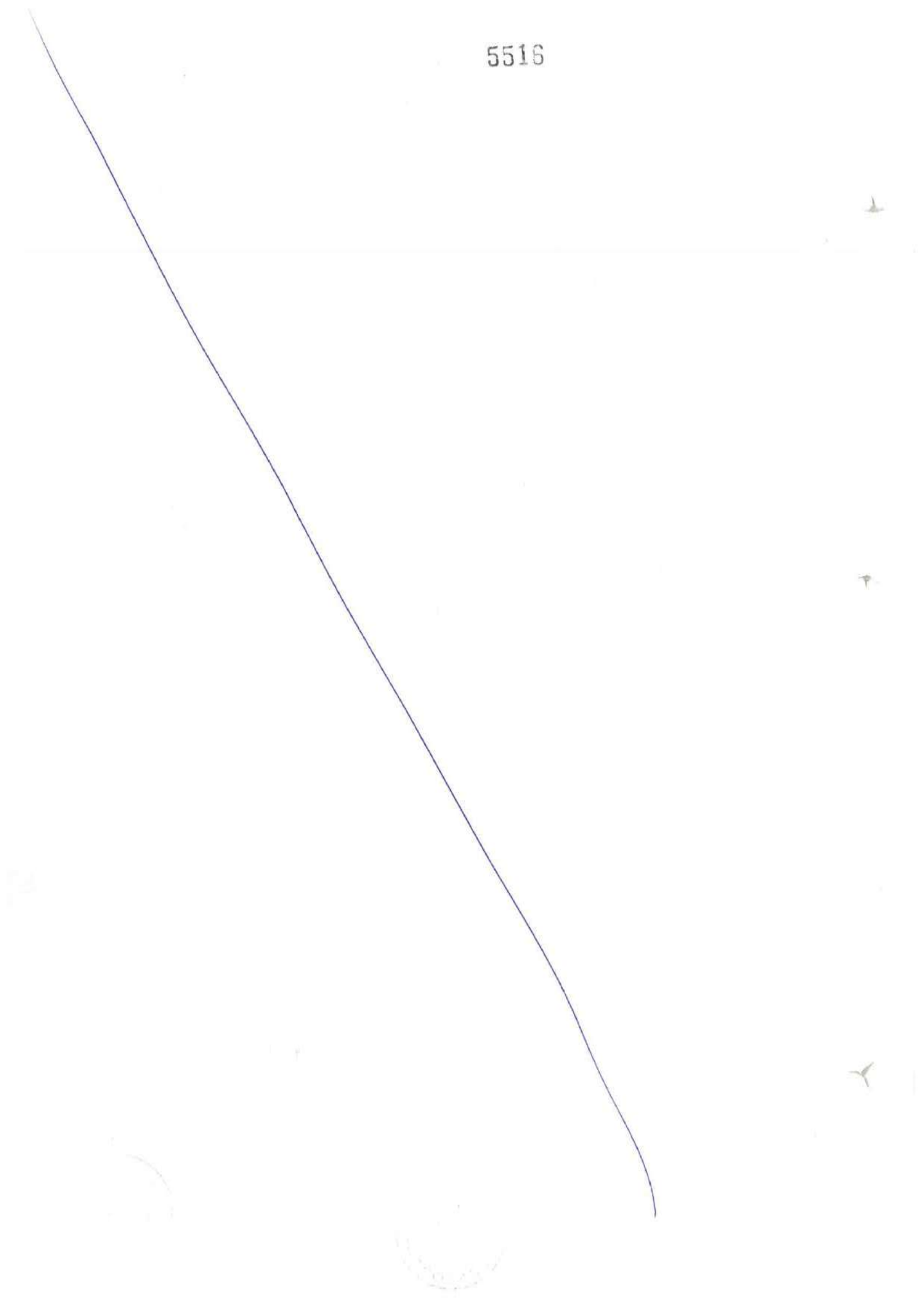
Wave heights shall be obtained from relevant Central Water and Power Research Station (CWPRS) guidelines and reports.

Abnormal waves shall be defined as having abnormality index,

$$AI = H_{max}/H_s \geq 2$$

Wave forces shall be calculated in accordance with:

- IS 4651 (Part III) 1997
- U.S. Army Coastal Research Centre Technical Report No.4. 'Shore Protection, Planning & Design'
- Department of the Army (USA) Coastal Engineering Research Centre 'Shore Protection Manual'.



Seismic loads (EQ)

The seismic loads shall be determined in accordance with IRC-6:2014, §219 and IS 1893, unless stated otherwise in this document.

5.3.5.1 General

Two levels of earthquake shall be considered:

- Maximum Considered Earthquake (MCE)
- Operating Basis Earthquake (OBE)

Seismic zone

The seismic zone for Mumbai obtained from IRC:6-2014, Figure 11, is Zone III.

Seismic zone factor

In accordance with IRC:6-2014, Table 7, for Zone III the zone factor, Z = 0.16.

Combinations of component motions

The seismic forces shall be assumed to come from the horizontal and vertical directions. Separate analyses shall be performed for design seismic forces in three orthogonal directions (x, y, z). In accordance with IRC:6-2014 notation, these axes are:

x = Horizontal direction of bridge longitudinal axis

y = Vertical direction

z = Horizontal direction perpendicular to bridge axis

The design seismic force resultants at any cross-section of a bridge component shall be shall be combined as stated in IRC:6-2014,§219.4,2) as follows:

a) $\pm r_1 \pm 0.3 \cdot r_2 \pm 0.3 \cdot r_3$

b) $\pm 0.3 \cdot r_1 \pm r_2 \pm 0.3 \cdot r_3$

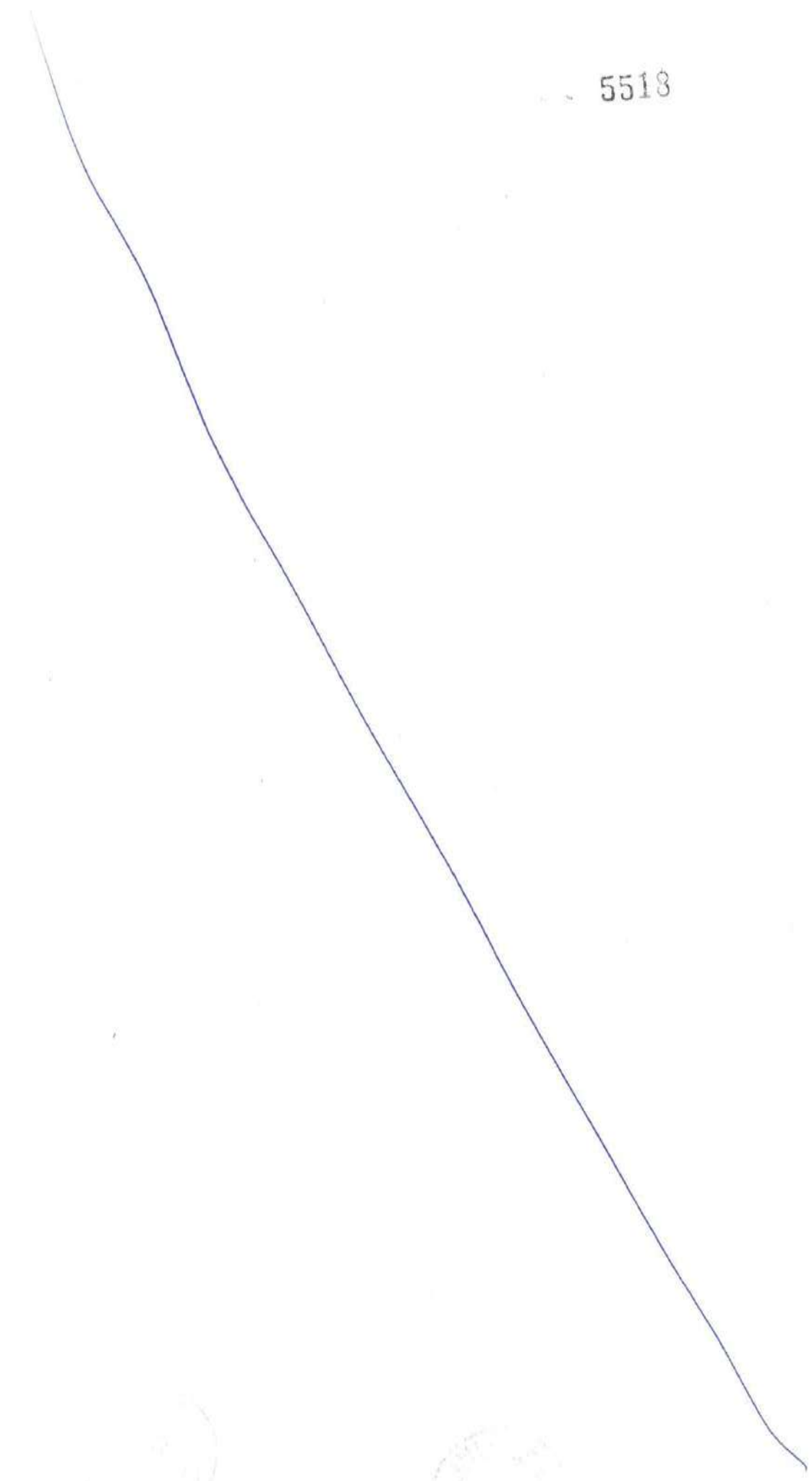
c) $\pm 0.3 \cdot r_1 \pm 0.3 \cdot r_2 \pm r_3$

where:

r_1 = Force resultant due to full design seismic force along x direction

r_2 = Force resultant due to full design seismic force along z direction

r_3 = Force resultant due to full design seismic force along vertical (y) direction



Seismic response spectrum

For Tender Design, the response spectrum for 'Type I (Rock or Hard Soil) N>30' in Figure 5-15 shall be used.

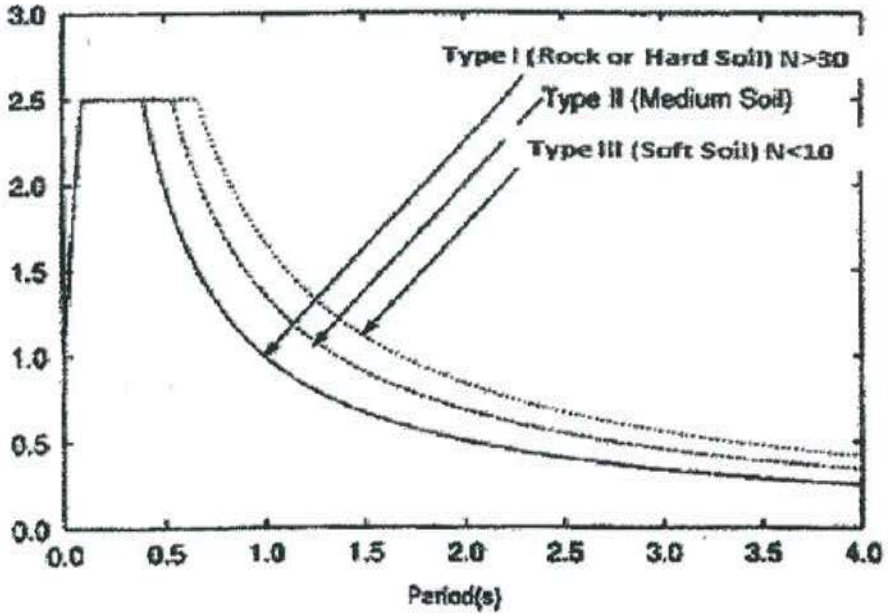


Figure 5-15 Seismic response spectrum

Design horizontal seismic coefficient

In accordance with IS 1893 (Part 1), §6.4.2, the design horizontal seismic coefficient, A_h, shall be calculated as follows:

› For Maximum Considered Earthquake (MCE), $A_h = {}^{Z.I.S_a}/_{R.g}$

› For Operating Basis Earthquake (OBE), $A_h = {}^{Z.I.S_a}/_{2.R.g}$

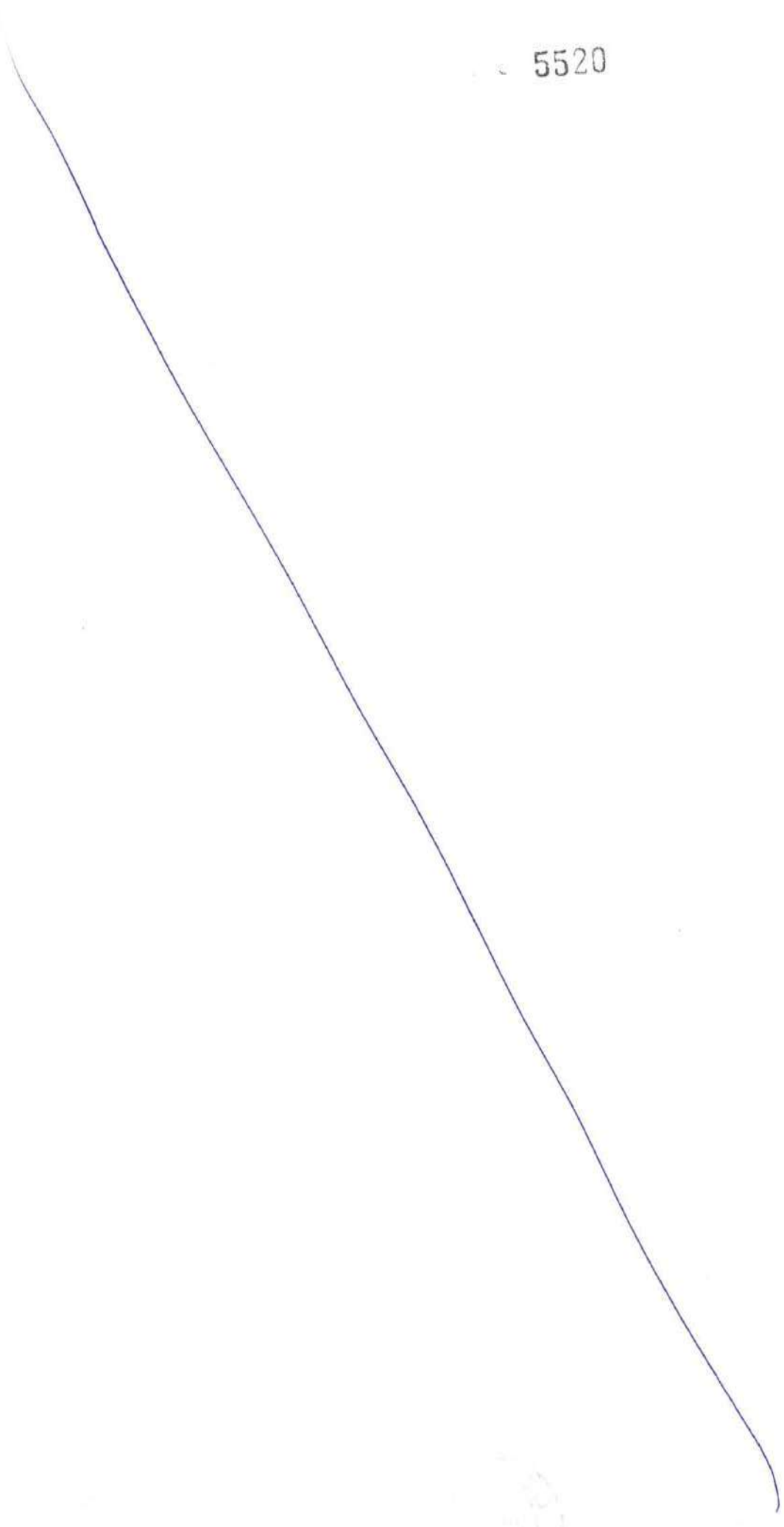
Average response acceleration coefficient

The type of soil considered for Tender Design shall be 'Type I soil with N>30'.

In accordance with IRC:6-2014, §219.5.1, the average response acceleration coefficient, S_a/g , for this soil type shall be taken as:

For $0.0 \le T \le 0.40$, $S_a/g = 2.50$

For $0.40 \le T \le 4.00$, $S_a/g = 1.00/T$



where, T = Fundamental period of the bridge (in sec.) for horizontal vibrations

Importance factor

In accordance with IRC:6-2014, §219.5.1, Table 8:

Importance factor, I = 1.5

Damping

In accordance with IRC:6-2014, §219.5.1:

- Reinforced concrete : 5% critical damping
- Pre-stressed concrete, steel : 2% critical damping

Response reduction factor

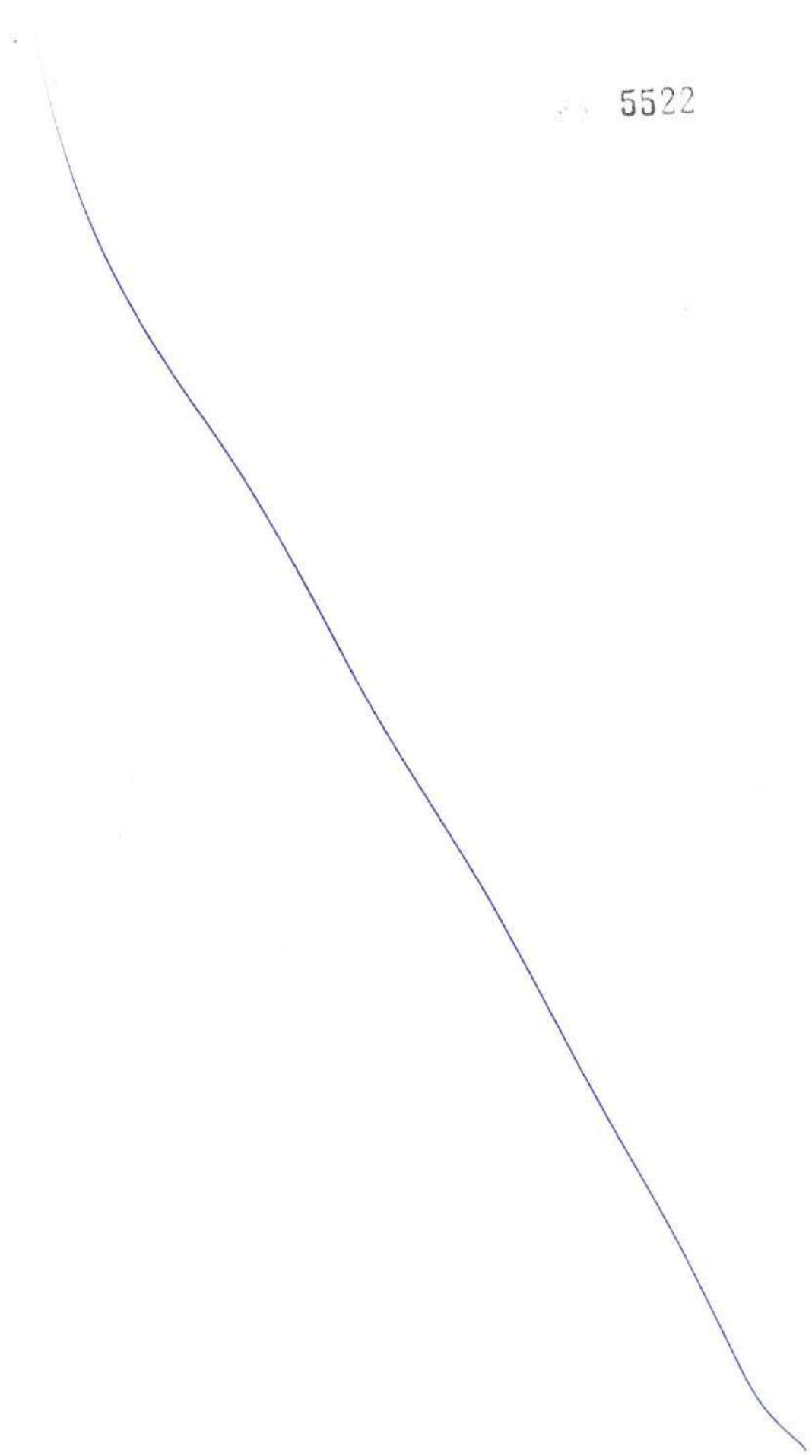
- MCE – For superstructures (i.e. above pile cap level) response reduction factors in accordance with IRC:6-2014, Table 9, may be used, provided that ductile detailing is also used (see §10.3). For segmental construction, R shall be taken as 1.0.
- OBE – Response reduction factors shall not be applied.

Foundation design

For structural design of the foundations for MCE, the seismic load shall be taken as 1.35 times the forces transmitted to it by the substructure.

For structural design of the foundations for OBE, the seismic load shall be taken as 1.0 times the forces transmitted to it by the substructure.

The foundation is understood to comprise the pile cap and piles.



5.4 ACCIDENTAL LOADS

Barge impact (BI)

The design vessel for barge impact forces shall have the following characteristics (ref. IRC:6-2017, §220):

- Vessel type: Barge
- Class of waterway: VI & VII
- DWT: 6000 tons
- Vessel speed: As per IRC:6-2017, §220.4.

The assumed vessel sailing path shall be the centre line of the navigation channel.

The minimum barge impact force to be considered shall be the greater of the following:

- Impact force calculated in accordance with IRC:6-2017, §220
- Impact force calculated in accordance with 'AASHTO Guide Specifications for Vessel Collision Design of Highway Bridges' (2009) (probabilistic method).

For details of barge collision analysis and design methodology, and for locations where barge impact forces shall be considered for design, see §0, below.

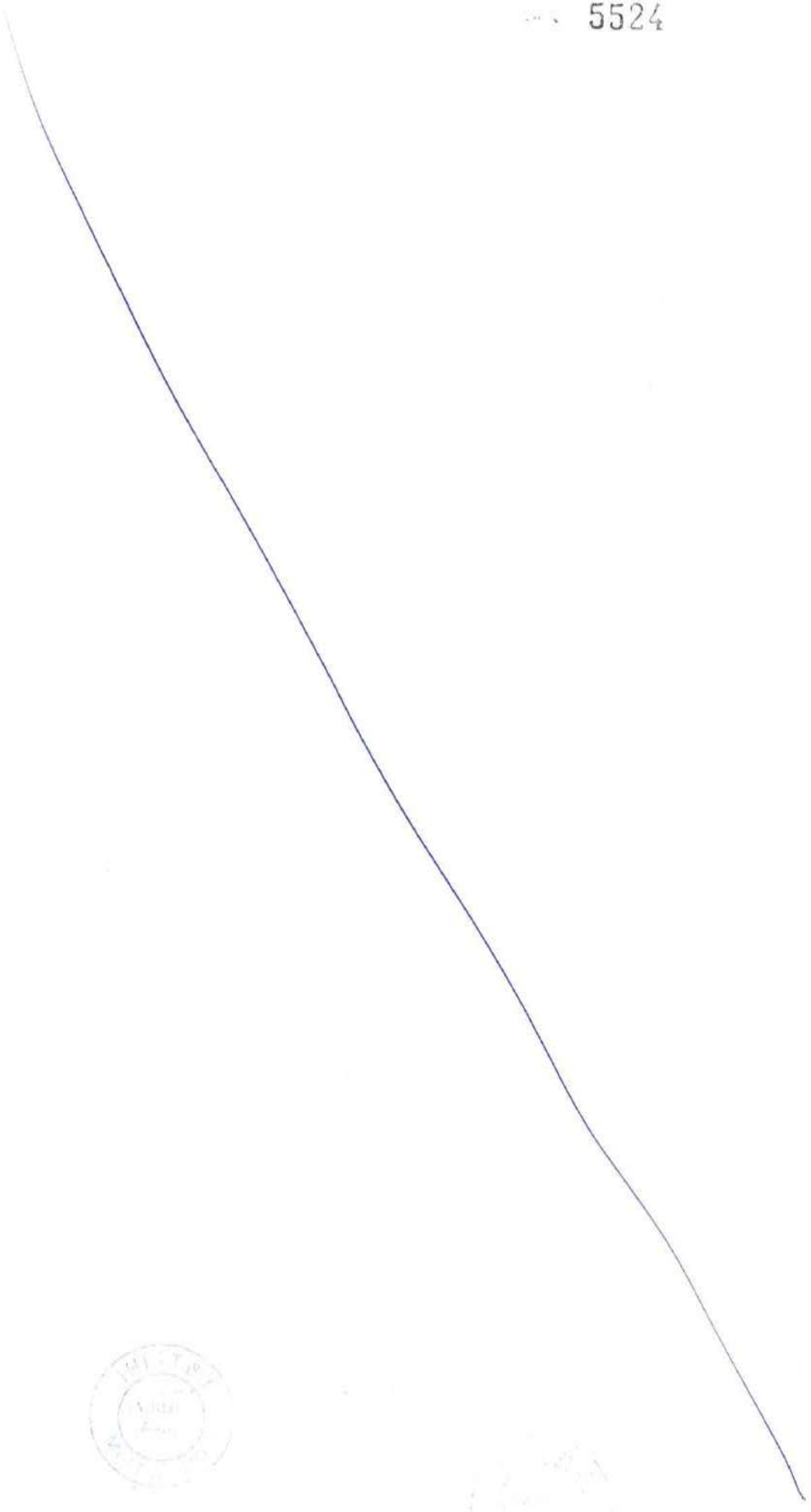
Vehicle crash barrier collision loads

Vehicle crash barriers shall be class P-3 High Containment type.

Vehicle crash barriers and bridge structures shall be designed to resist the loads for P-3 High Containment type barriers stated in IRC:6-2017, §206.6.

Road vehicle impact with bridge pier

Road vehicle impact forces on bridge piers shall be considered in accordance with IRC:6-2017, §222.



5.5 FATIGUE LOAD

Fatigue loading shall be in accordance with IRC:6-2017, § 204.6.

A fatigue truck with total weight 40 tonnes shall be used to obtain fatigue load effects. The axle loads and axle spacing are show in Figure 5-16. The transverse wheel spacing and tyre arrangement are shown in Figure 5-17.

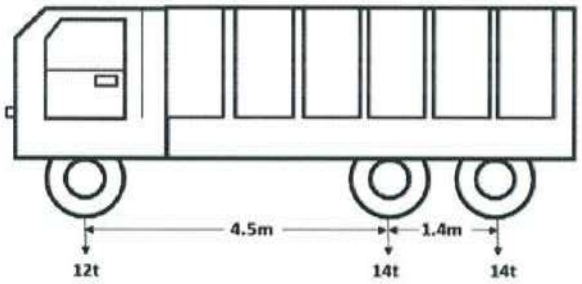


Figure 5-16 Fatigue truck – Axle loads and axle spacing

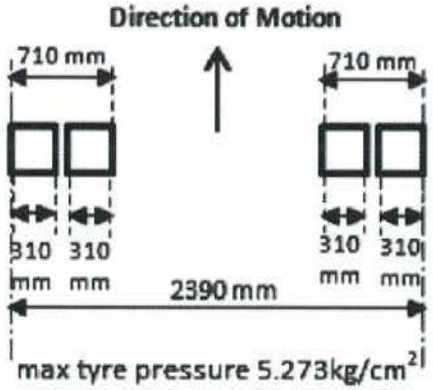
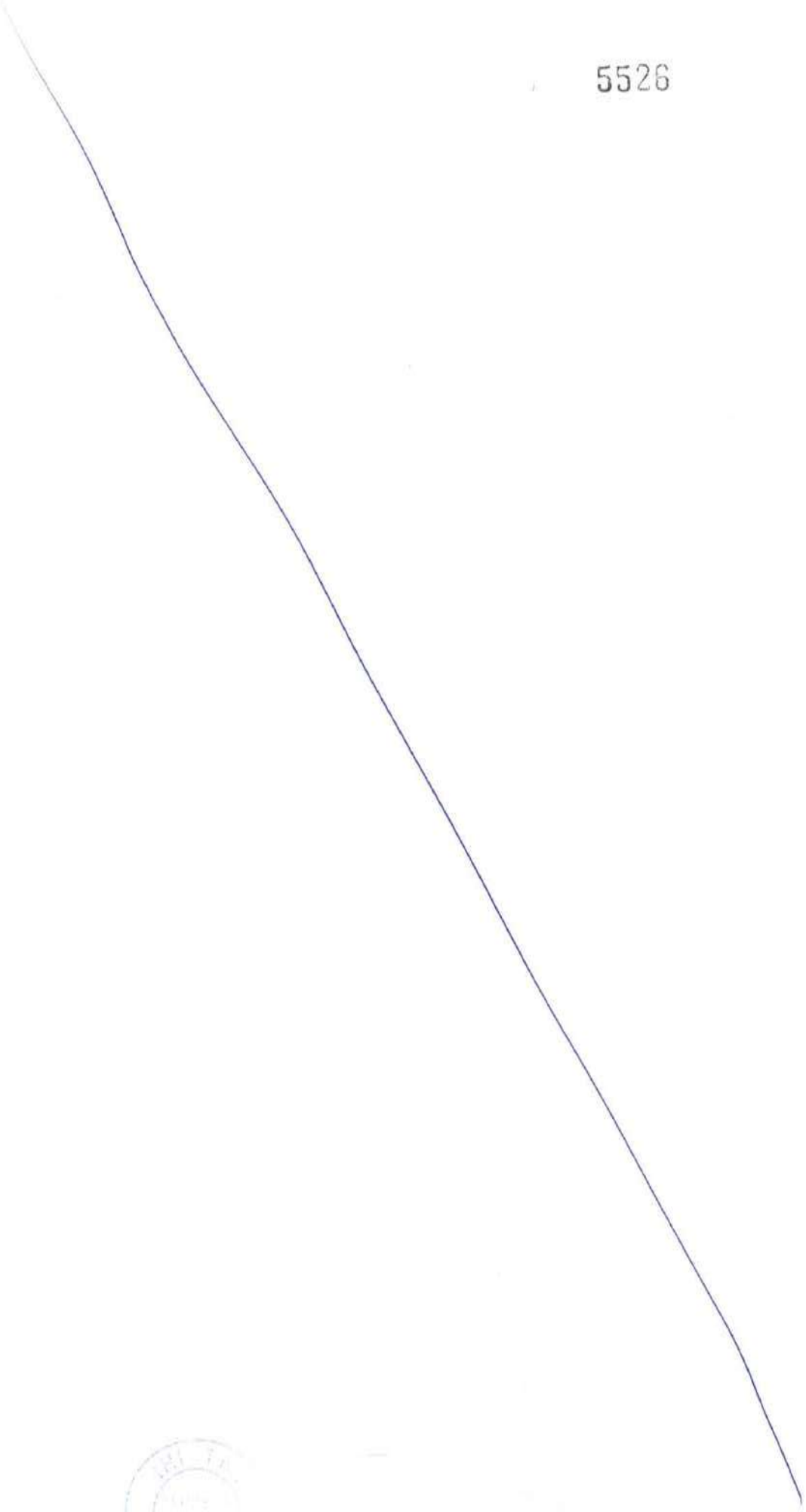


Figure 5-17 Fatigue truck – Transverse wheel spacing and tyre arrangement

Impact factors equal to 50% of the impact factors determined in accordance with §**Error! Reference source not found.**, above, shall be applied.

The fatigue truck shall be positioned to have the worst effect of the detail or element of the bridge under consideration.

The minimum clearance between the outer edge of the wheel of the fatigue vehicle and the roadway face of the kerb shall be 150 mm.



Bridges shall be designed for the stresses induced by 10×10^6 cycles.

5.6 ACCESS/MAINTENANCE FACILITY LIVE LOADS

Inspection gantries

Imposed live loading on inspection gantries to the steel bridges shall be:

- UDL = 5 kN/m²
- Point load = 75 kN, placed anywhere on the gantry

Access walkways in box girders

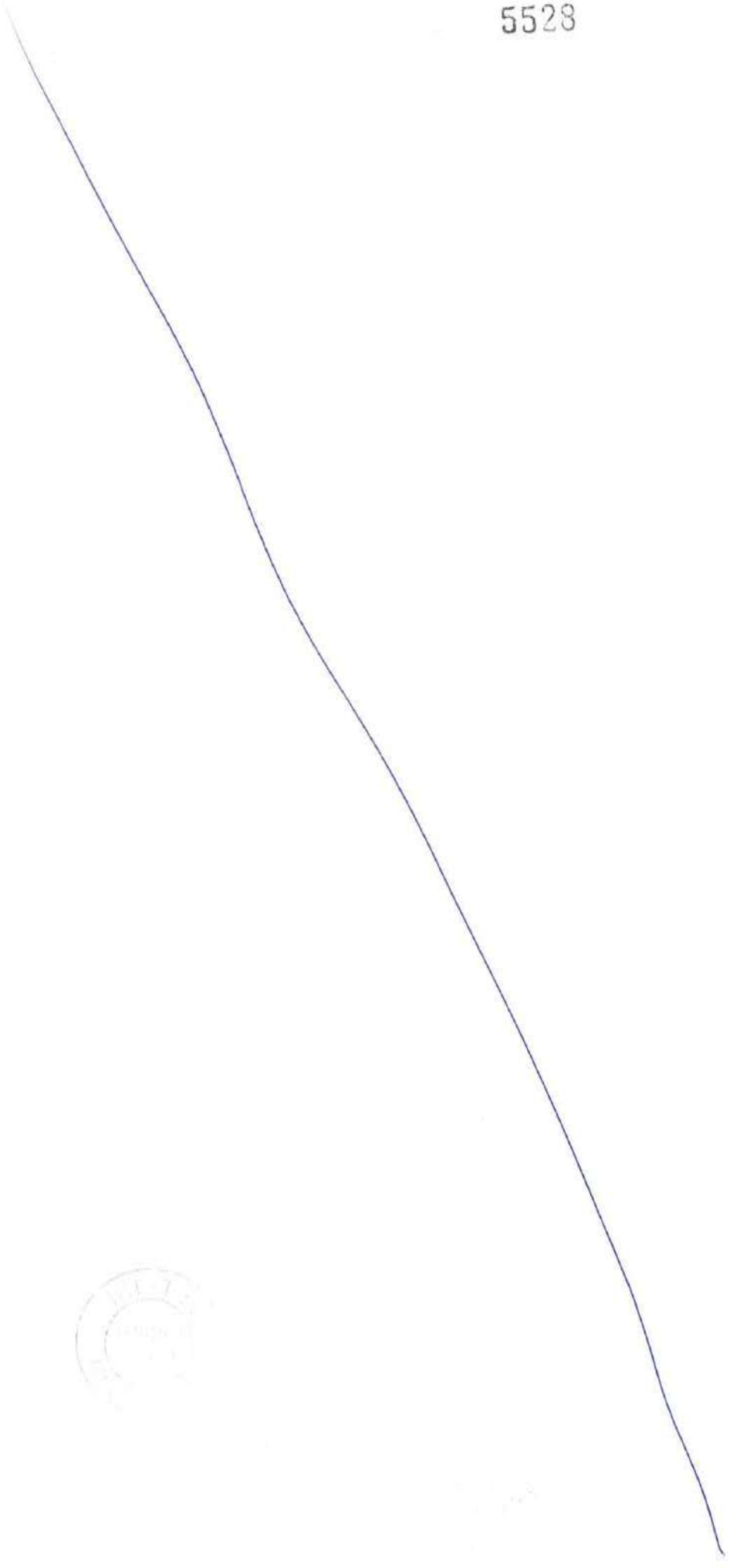
Imposed live loading shall be:

- UDL = 2 kN/m² (global analysis)
- Concentrated load = 3 kN, on an area 0.2 m x 0.2 m (local analysis)

Access walkways at piers tops

Imposed live loading shall be:

- UDL = 5 kN/m²
- Concentrated Load = 75 kN



6 LOAD COMBINATIONS

6.1 CONCRETE STRUCTURES

The load combinations for concrete structures used for Tender Design are in accordance with IRC:6-2017, Annex B, Tables B.1 to B.4.

Serviceability limit states (SLS)

Load combinations for SLS are presented in **Error! Reference source not found.**.

Rare (R) Load Combinations shall be used for checking stress limits, in accordance with IRC:6-2017, Annex B, §7.1.

Frequent (F) Load Combinations shall be used for checking the deflections, vibrations and crack widths in pre-stressed concrete structures in accordance with IRC:6-2017, Annex B, §7.2. Frequent load combinations shall also be used for checking crack widths for pre-stressed members with bonded tendons, in accordance with IRC:112-2011, Table 12.1.

Quasi-Permanent (QP) Load Combinations shall be used for checking crack widths in reinforced concrete structures, settlement, creep effects and the estimation of permanent stress in structures, in accordance with IRC:6-2017, Annex B, §7.3 of. IRC:112-2011, Table 12.1 also specifies that quasi-permanent combinations shall be used for checking crack widths in reinforced members and pre-stressed members with un-bonded tendons.

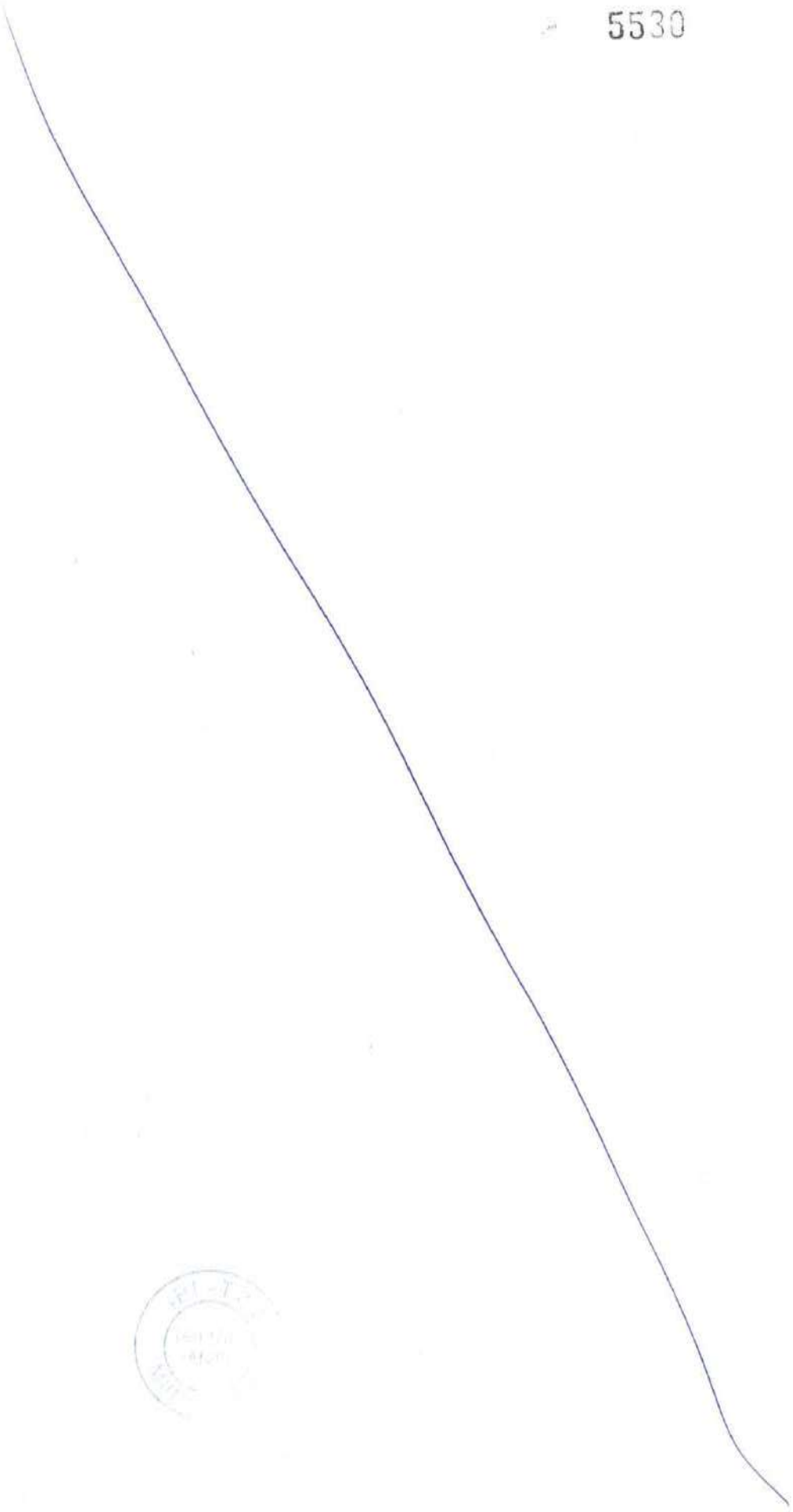
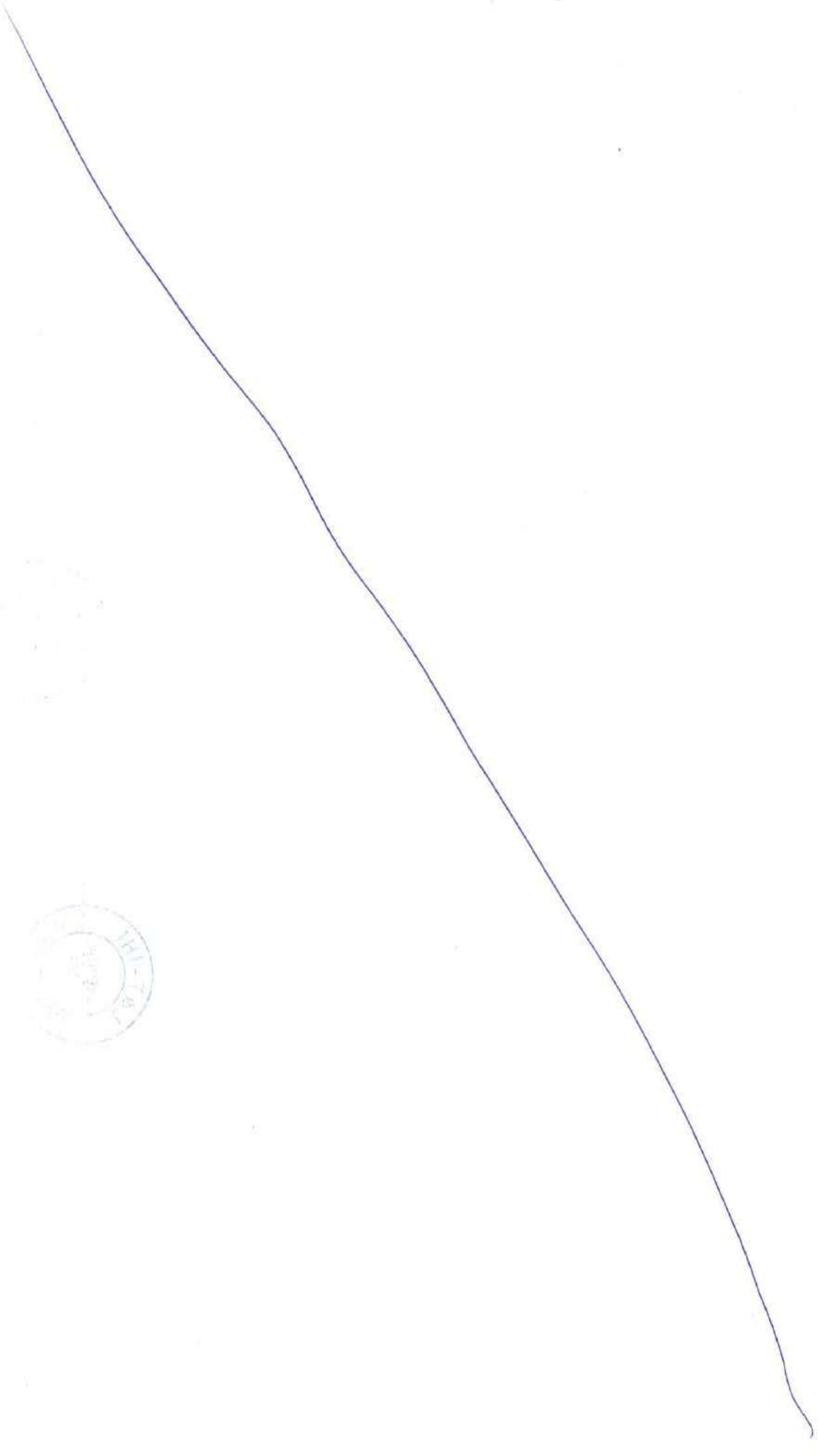
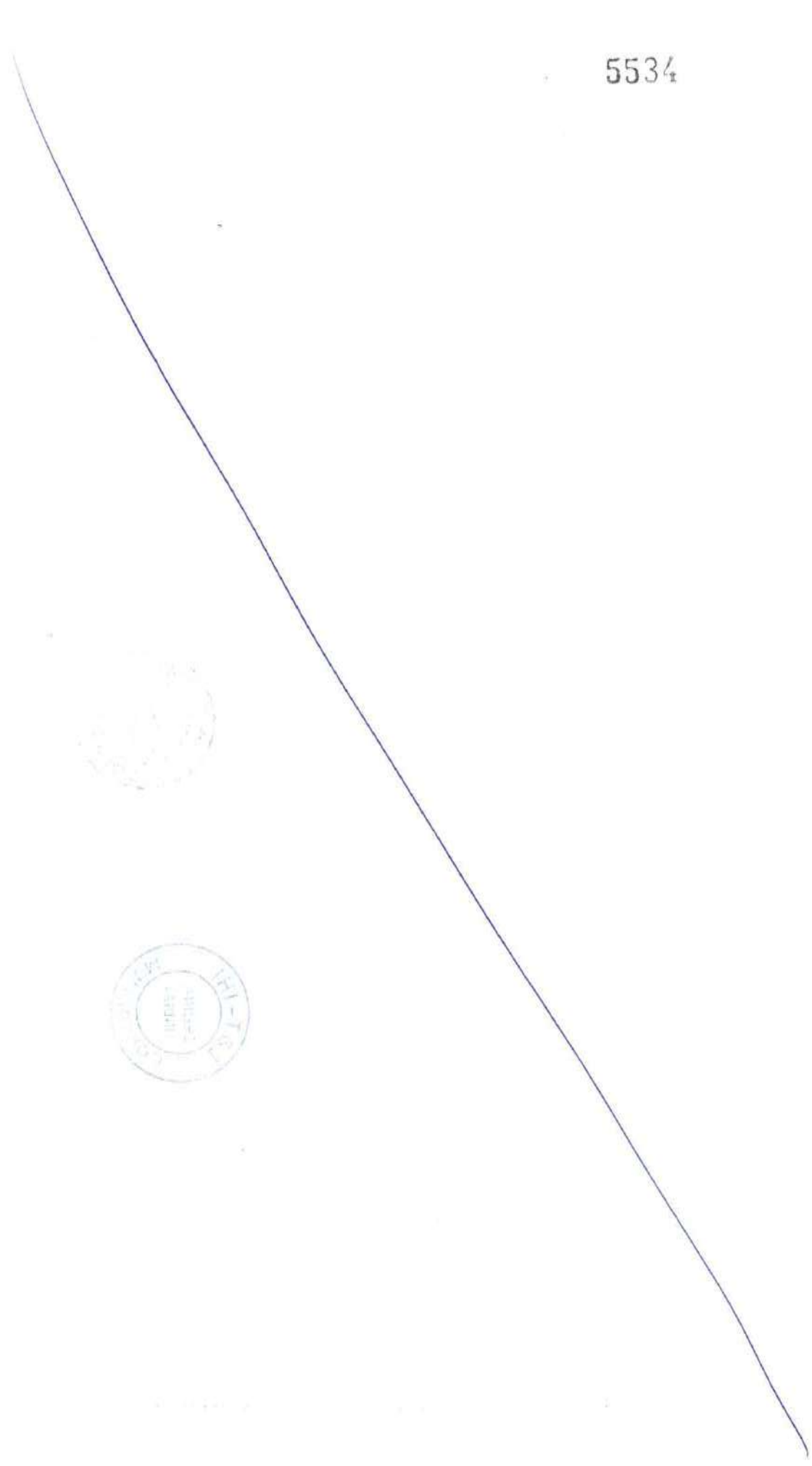


Table 6-1 Load Combinations for SLS

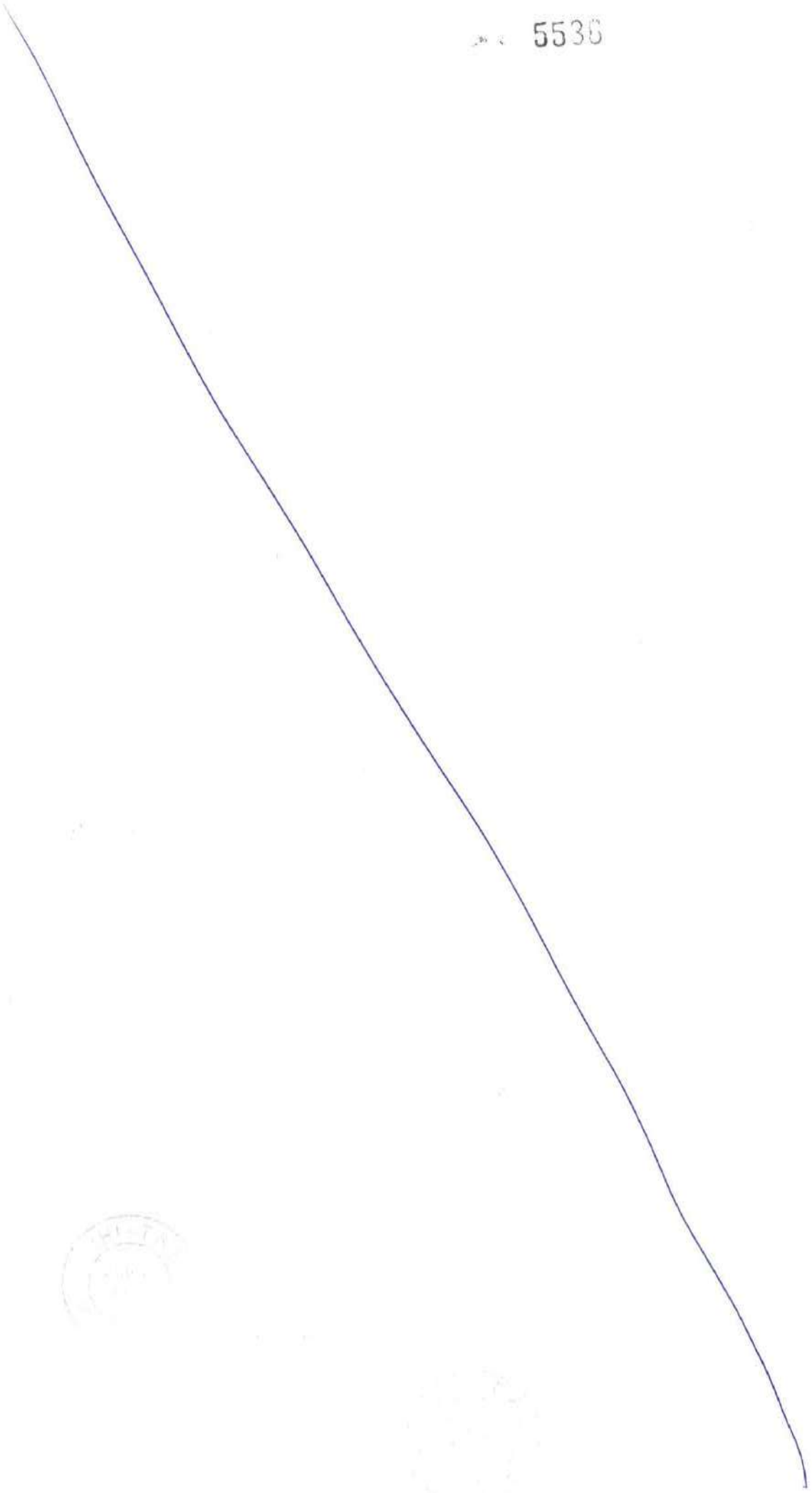
Load Combination	R1a (CLL)	R1b (CLL)	R2a (W)	R2b (W)	R3 (T)	F1a (CLL)	F1b (CLL)	F2a (W)	F2b (W)	F3 (T)	QP1 (EQ)
1. Permanent loads											
1.1 Dead load (DL), superimposed dead load (except surfacing) (SIDL)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.2 Surfacing [3]	1.2/1.0	1.2/1.0	1.2/1.0	1.2/1.0	1.2/1.0	1.2/1.0	1.2/1.0	1.2/1.0	1.2/1.0	1.2/1.0	1.2/1.0
1.3 Earth pressure due to backfill	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.4 Prestress and secondary effect of prestress (P):											
Pre-tensioning or unbonded tendons [1]	1.05/0.95	1.05/0.95	1.05/0.95	1.05/0.95	1.05/0.95	1.05/0.95	1.05/0.95	1.05/0.95	1.05/0.95	1.05/0.95	1.05/0.95
Post-tensioning with bonded tendons [1]	1.1/0.90	1.1/0.90	1.1/0.90	1.1/0.90	1.1/0.90	1.1/0.90	1.1/0.90	1.1/0.90	1.1/0.90	1.1/0.90	1.1/0.90
1.5 Shrinkage and creep effect	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2. Settlement effects [4]	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0
3. Variable loads [7]											
3.1 Carriageway Live Loads (CLL) [10] Vehicular Live Loads [2] [11] Horizontal forces	1.0	1.0	0.75	-	0.75	0.75	0.75	0.2	-	0.2	-
3.2 Thermal load (T)[10]											
Thermal Actions (Uniform & Gradient) [6]	-	0.6	-	-	1.0	-	0.5	-	-	0.6	0.5
Bearing friction/Portal frame restraint [8]	-	0.6	-	-	1.0	-	0.5	-	-	0.6	0.5



3.3 Wind load (W) [9]	0.6	-	1.0	1.0	-	0.5	-	0.6	0.6	-	-
3.4 Live load surcharge (accompanying load)	0.8	0.8	0.8	-	0.8	-	-	-	-	-	-
4. Hydraulic loads (accompanying load)											
4.1 Water current	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-
4.2 Wave pressure	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-
For Notes to Table 6-1, see following page.											



Notes to Table 6-1
1) Two characteristic values of prestressing shall be used as per IRC:112-2011, §7.9.5, (6), i.e. superior/ inferior value. If the tensioning force applied to any tendon is determined by direct measurement of the jack gauge reading and checked by measurement of the elongation of the tendon $\gamma_{inf} = \gamma_{sup} = 1.0$ following EN 1992-1-1 section 5.10.9
2) Live load shall be combined as described in per §5.2 of this document.
3) Adding to / Relieving the effect of variable loading.
4) Adding to / Opposing the permanent load.
5) Leading actions marked in grey.
6) Temperature load shall be as per §5.3.2 of this document.
7) Variable loads produce favourable (relieving) effects shall be ignored.
8) Bearing friction/Portal frame restraint resulting from sliding bearings. Bearing friction from elastomeric bearings shall be considered in conjunction with thermal gradient load.
9) Different wind speeds shall be considered with and without coexistent traffic loading, see §5.3.1
10) If the congestion factor is taken into consideration the horizontal forces from live load (braking, traction & centrifugal forces) and temperature shall be omitted. Impact factor shall still be included.
11) For Special Vehicle (SV) live load, partial load factor for SLS = 1.0



Ultimate limit states (ULS)

Load combinations for ULS are presented in Table 6-2, Table 6-3**Error! Reference source not found.** and Table 6-4.

Equilibrium (ULS-EQU) Ultimate Limit State shall be verified in order to avoid overturning, sliding, and uplift. It shall be ensured that the destabilizing loads are always less than the stabilizing or restoring actions. Relevant combinations are indicated by 'B' (Basic), 'A' (Accidental) or 'S' (Seismic).

Structural Strength (ULS-STR) Ultimate Limit State shall be verified in order to avoid internal failure or excessive deformation. Relevant combinations are indicated by 'B' (Basic), 'A' (Accidental) or 'S' (Seismic).

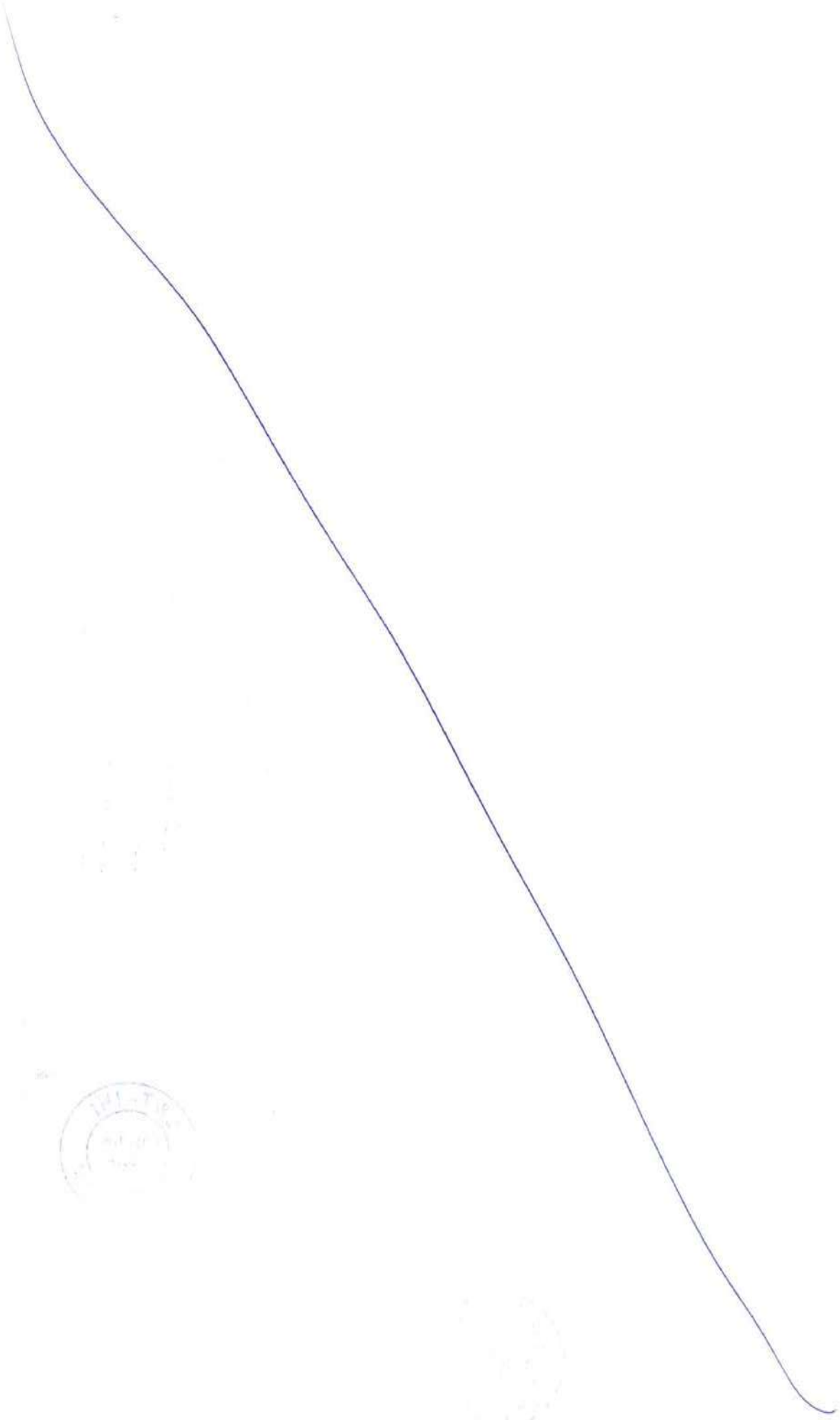
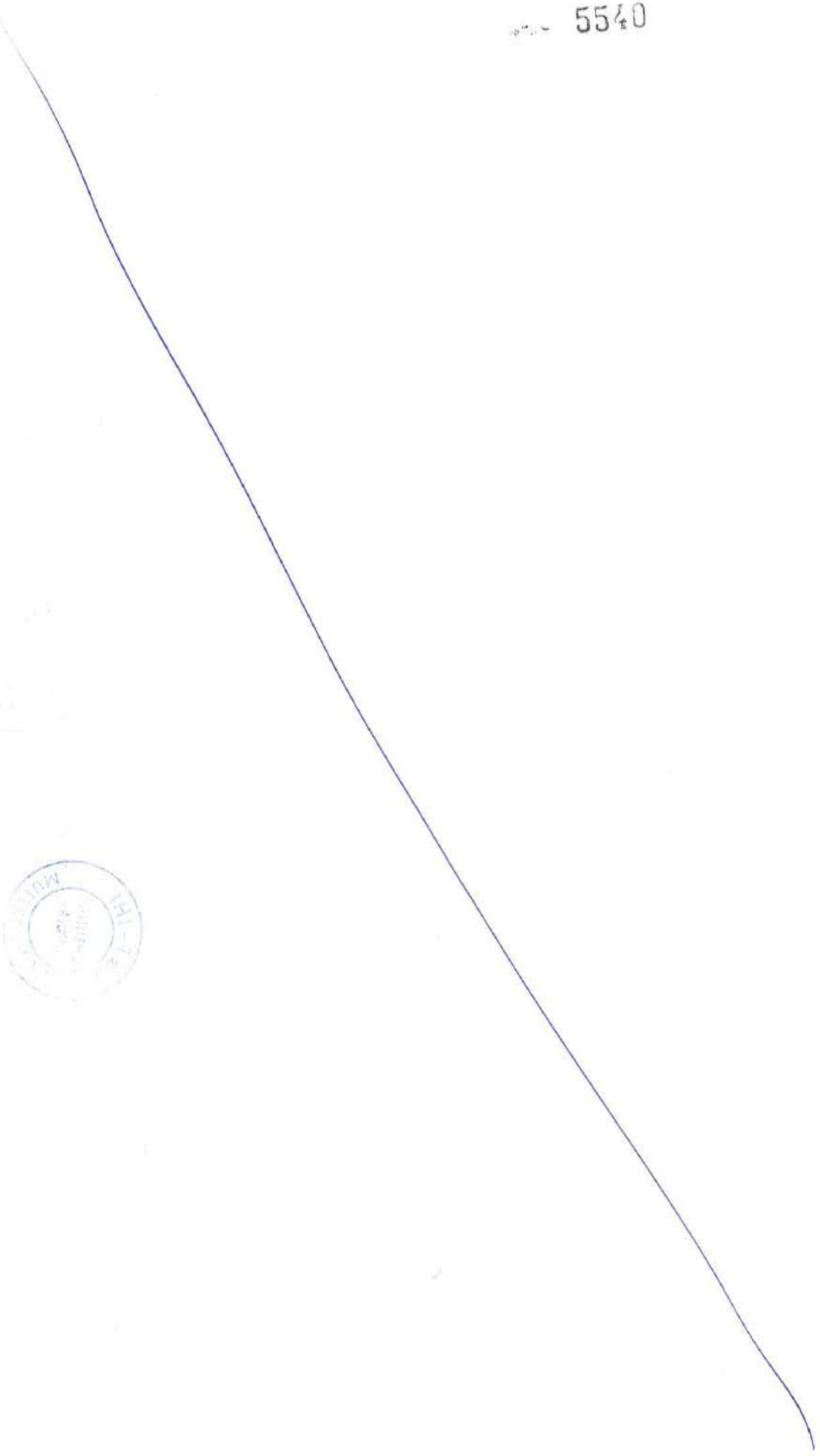
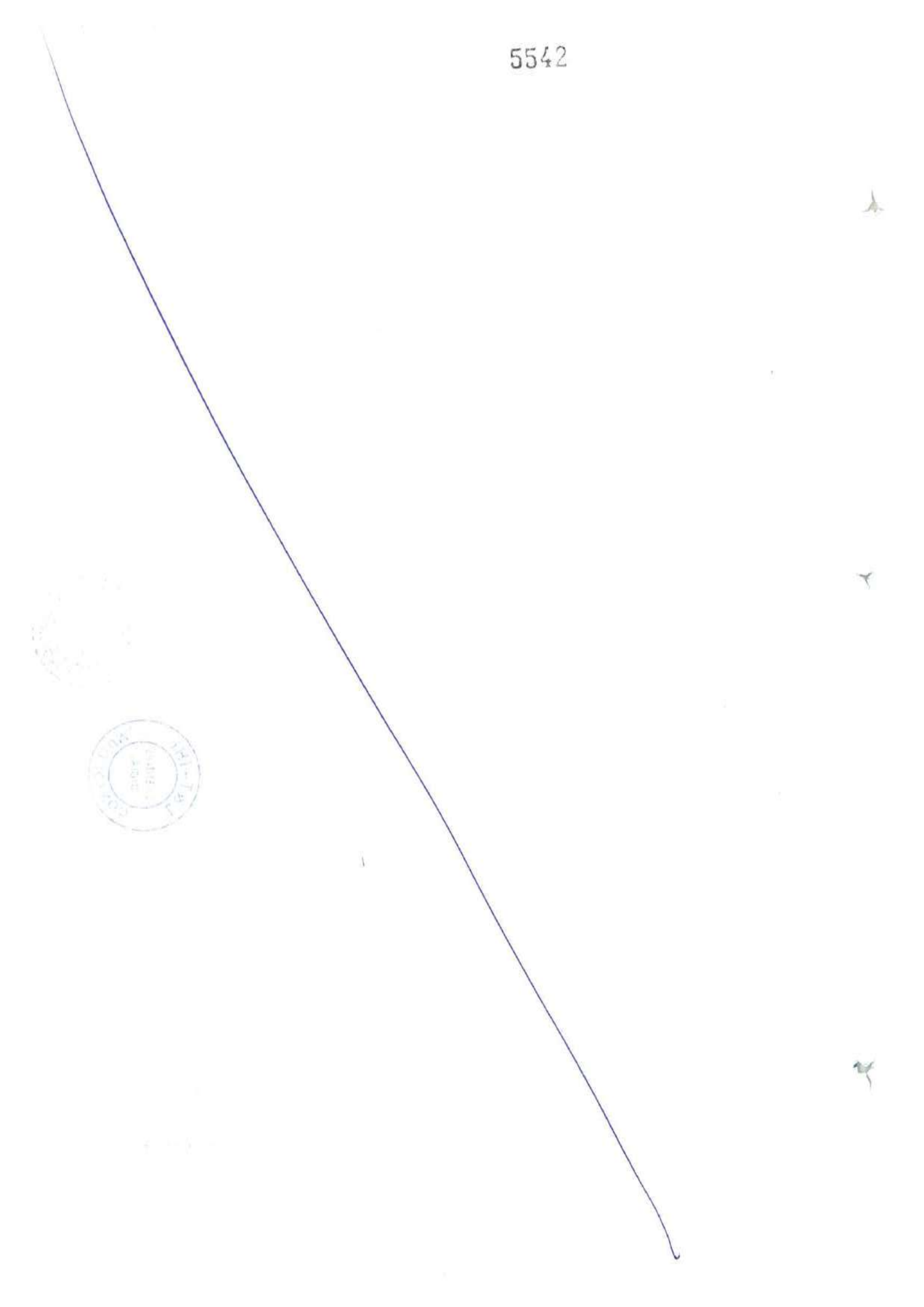


Table 6-2 Load Combinations for ULS-EQU

Load Combination	B1a (CLL)	B1b (CLL)	B2a (W)	B2b (W)	B4 (T)	A1 (BI)	S1[2] (EQ)
1. Permanent Loads							
1.1 Dead load (DL) [10] Superimposed Dead Load (except surfacing) (SIDL) [10]	1.05/0.95	1.05/0.95	1.05/0.95	1.05/0.95	1.05/0.95	1.0/1.0	1.05/0.95
1.2 Surfacing [10]	1.35/1.0	1.35/1.0	1.35/1.0	1.35/1.0	1.35/1.0	1.0/1.0	1.35/1.0
1.3 Prestress and secondary effect of prestress (P):							
External/unbonded tendons[1,10]	1.25/0.8	1.25/0.8	1.25/0.8	1.25/0.8	1.25/0.8	1.25/0.8	1.25/0.8
1.4 Backfill weight[10] (soil over pile cap if any)	1.05/0.95	1.05/0.95	1.05/0.95	1.05/0.95	1.05/0.95	1.0/1.0	1.05/0.95
1.5 Creep and shrinkage [10]	1.05/0.95	1.05/0.95	1.05/0.95	1.05/0.95	1.05/0.95	1.0/1.0	1.05/0.95
1.6 Settlement effects [10]	1.05/0.95	1.05/0.95	1.05/0.95	1.05/0.95	1.05/0.95	1.0/1.0	1.05/0.95
2. Variable Loads [6]							
2.1 Carriageway Live Loads (CLL)[14] Vehicular Live Loads [8) 15] Horizontal forces	1.5	1.5	1.15	-	1.15	0.2	0.2
2.2 Thermal loads (T)							
Thermal Actions (Uniform & Gradient)	-	0.9	-	-	1.5	0.5	0.5
Bearing friction [12]	-	0.9	-	-	1.5	0.5	0.5
2.3 Wind load (W) [13]	0.9	-	1.5	1.5	-	-	-
2.4 Live load surcharge (accompanying load)	1.2	1.2	1.2	-	1.2	-	-
3. Accidental Effects [9]							
3.2 Barge impact (BI)	-	-	-	-	-	1.0	-

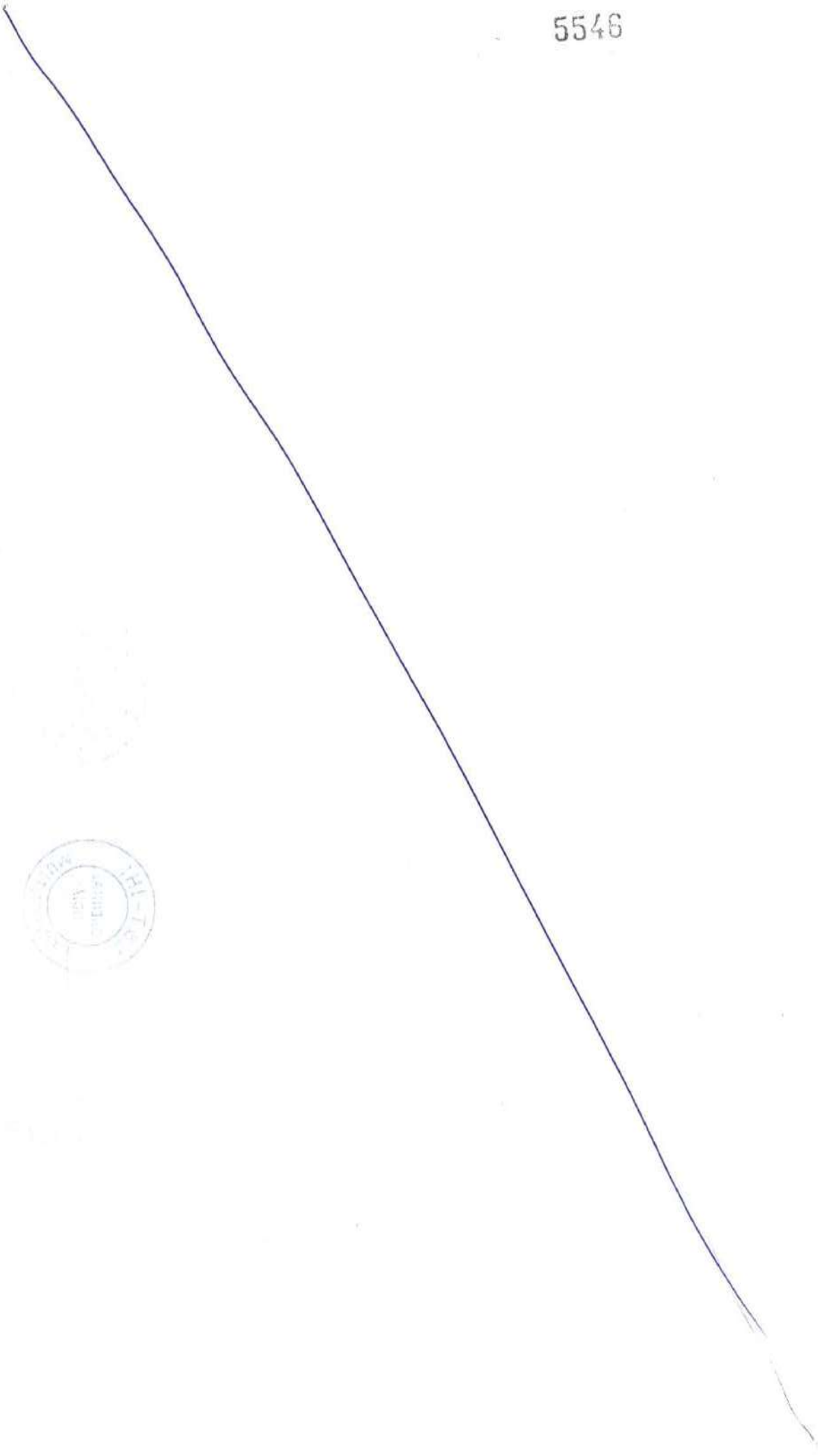


4.	**Seismic effect (EQ)**							
	a) during service	-	-	-	-	-	-	1.5
6.	**Hydraulic Loads** (accompanying load)							
6.1	Water current force[10)]	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0
6.2	Wave pressure[10)]	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0
6.3	Hydrodynamic effect[10)]	-	-	-	-	-	-	1.0/0
For Notes to Table 6-2, see following page.								

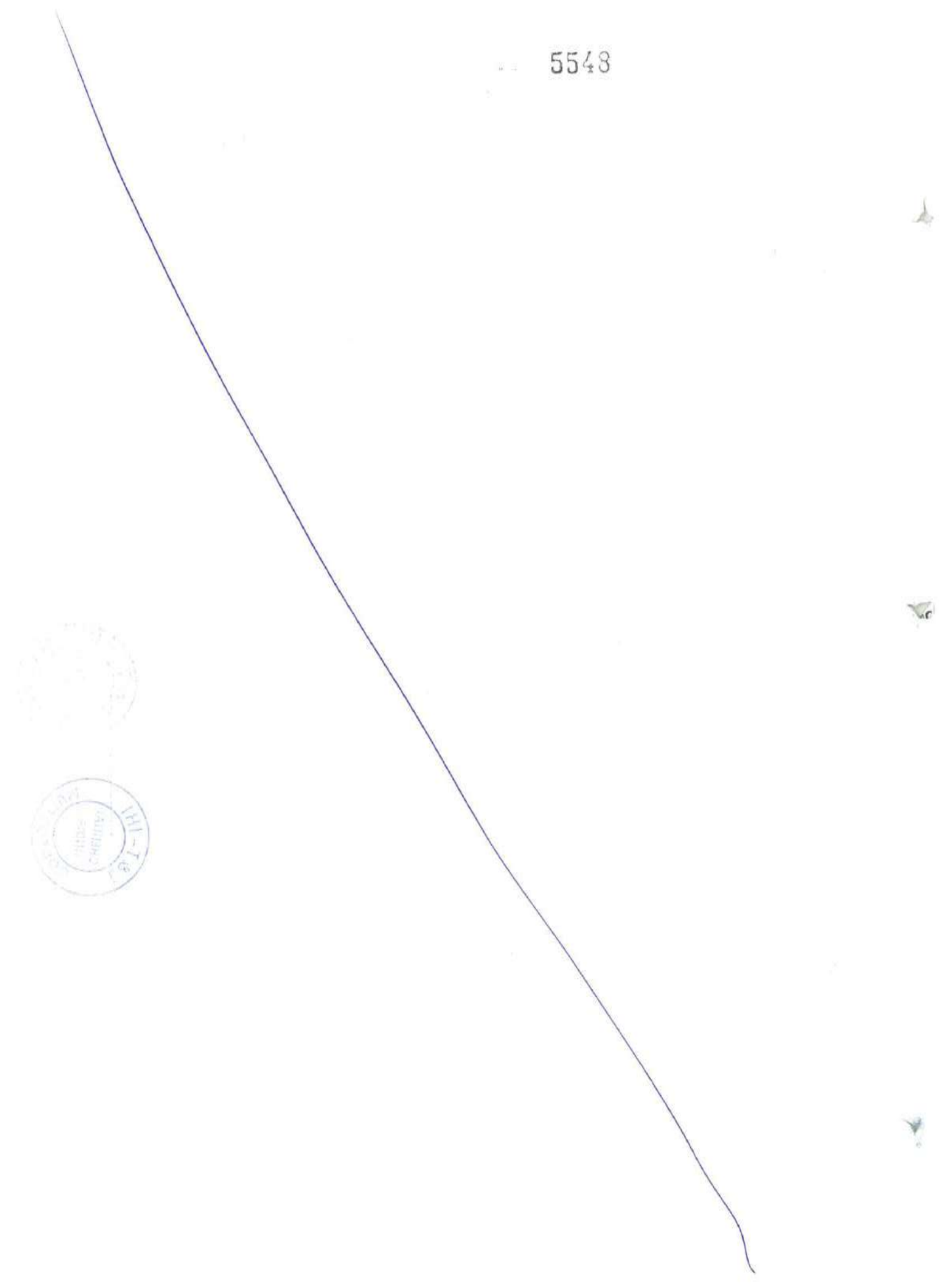


Notes to Table 6-2
1) See §7.9.5 of IRC:112-2011
2) Dead load, SIDL and (appropriate) live load shall not be enhanced (factored) by corresponding partial safety factors for calculation of time period and seismic force.
3) Seismic effects shall be combined as per §5.3.5 of this document.
4) Adding to / Relieving the effect of variable loading.
5) Leading actions marked in grey.
6) Any variable loads producing favourable (relieving) effects shall be ignored.
8) Vehicular live load shall be combined as per §5.2 of this document.
9) Only one of the accidental load shall be considered at a time.
10) Overturning/restoring
11) Temperature load shall be combined as per §5.3.2 of this document.
12) Bearing friction resulting from sliding bearings. Bearing friction from elastomeric bearings shall be considered in conjunction with thermal gradient load.
13) Different wind speeds shall be considered with and without coexistent traffic loading, see §5.3.1.
14) If the congestion factor is taken into consideration the horizontal forces from live load (braking, traction & centrifugal forces) and temperature shall be omitted. Impact factor shall still be included.
15) For Special Vehicle (SV) live load, partial load factor for ULS = 1.0

Table 6-3 Load Combinations for ULS-STR (excluding foundations)



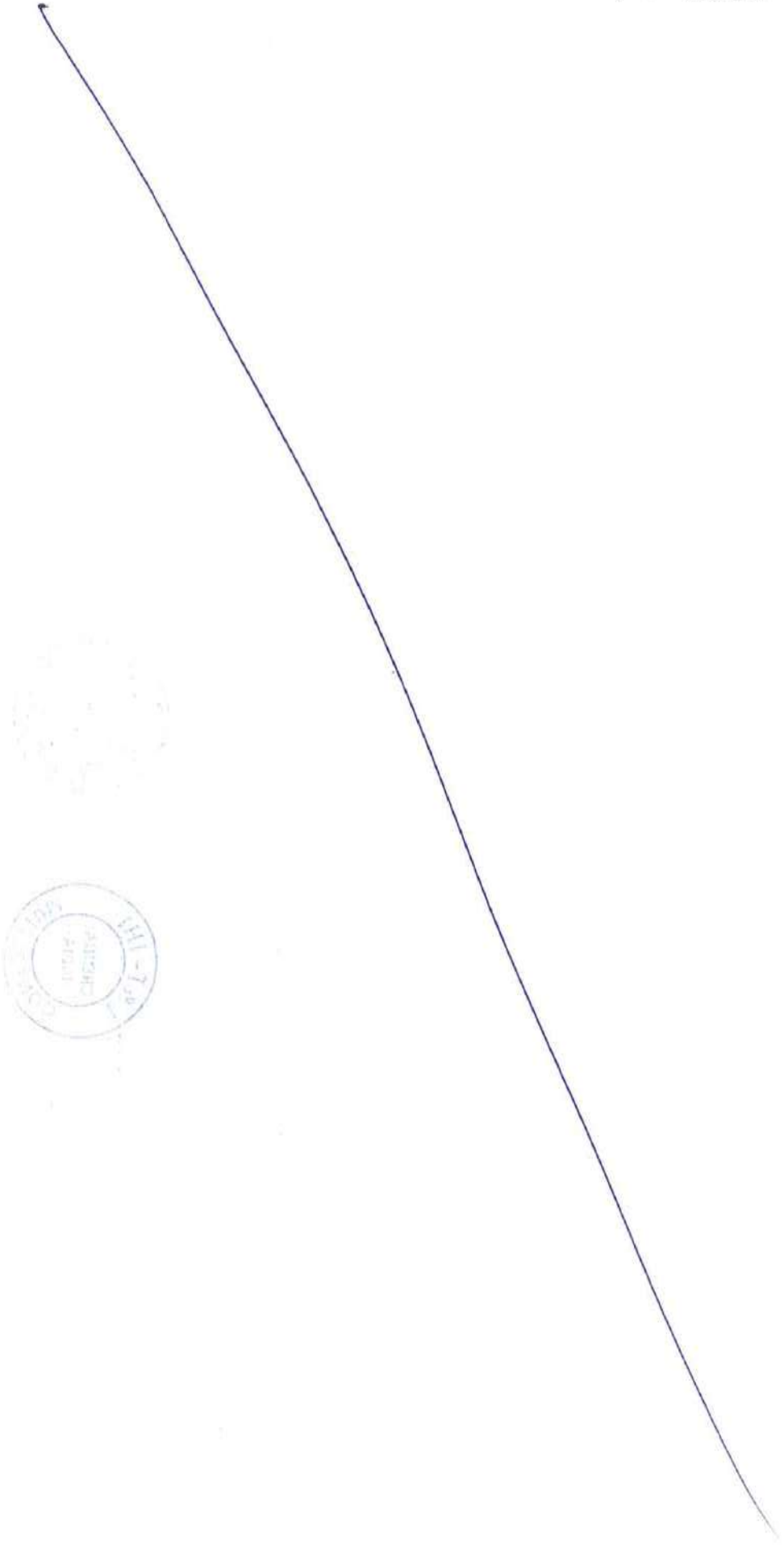
Load Combination	B1a (CLL)	B1b (CLL)	B2a (W)	B2b (W)	B4 (T)	A1 (BI)	S1 [2] (EQ)
1. Permanent Loads							
1.1 Dead load (DL) [4] Superimposed Dead Load (except surfacing) (SIDL) [4]	1.35/1.0	1.35/1.0	1.35/1.0	1.35/1.0	1.35/1.0	1.0/1.0	1.35/1.0
1.2 Surfacing [4]	1.75/1.0	1.75/1.0	1.75/1.0	1.75/1.0	1.75/1.0	1.0/1.0	1.75/1.0
1.3 Prestress and secondary effect of prestress (P) [1]	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.4 Backfill weight	1.5	1.5	1.5	1.5	1.5	1.0	1.0
1.5 Earth pressure due to backfill [4]	1.5/1.0	1.5/1.0	1.5/1.0	1.5/1.0	1.5/1.0	1.0/1.0	1.5/1.0
2. Variable Loads [6]							
2.1 Carriageway Live Loads (CLL) [14] Vehicular Live Loads [8] [15] Horizontal forces	1.5	1.5	1.15	-	1.15	0.2	0.2
2.2 Wind load (W) [13]	0.9	-	1.5	1.5	-	-	-
2.3 Live load surcharge (accompanying) [4]	1.2/0	1.2/0	1.2/0	1.2/0	1.2/0	0.2/0	0.2/0
2.5 Thermal loads (T)							
Thermal Actions (Uniform & Gradient)	-	0.9	-	-	1.5	0.5	0.5
Bearing friction [12]	-	0.9	-	-	1.5	0.5	0.5
3. Accidental Effects [9]							
3.1 Barge impact (BI)	-	-	-	-	-	1.0	-



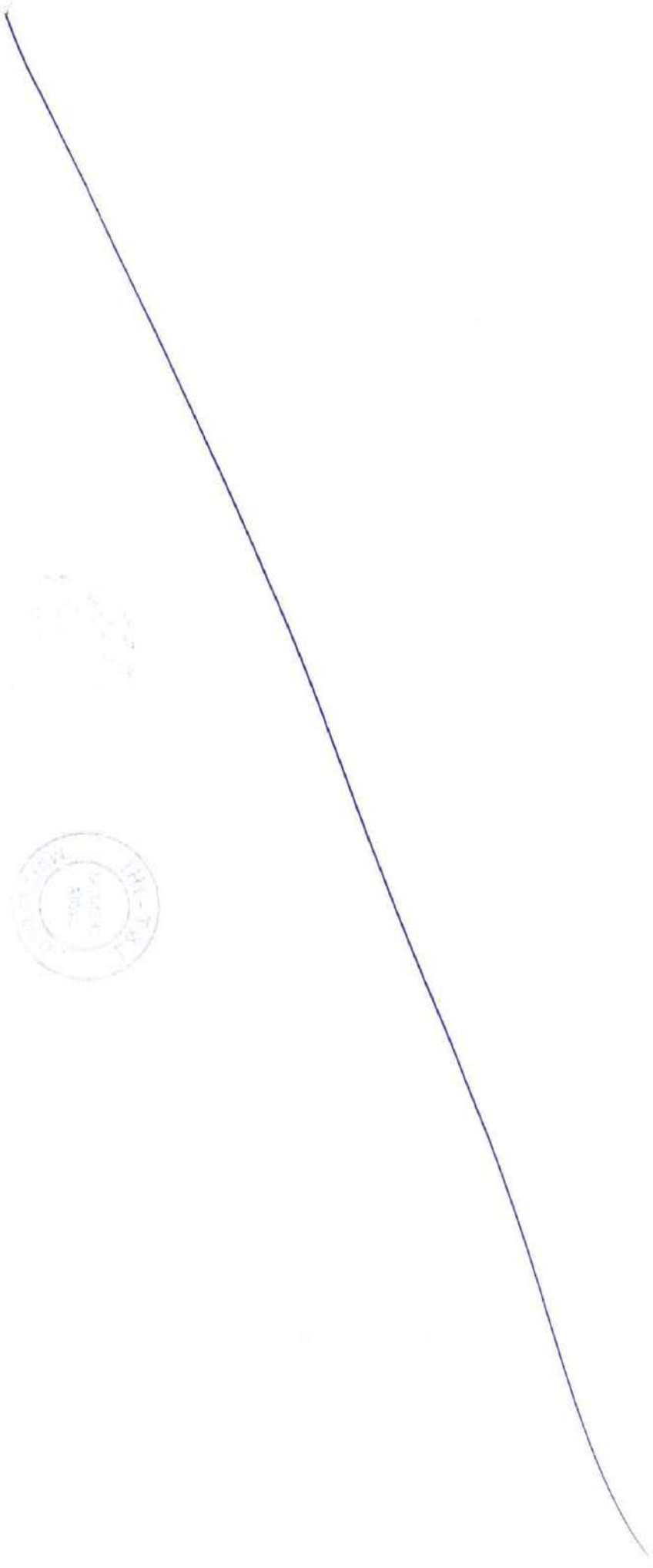
4. Seismic effect (EQ)							
a) during service	-	-	-	-	-	-	1.5
5. Hydraulic Loads (accompanying load)							
5.1 Water current force[4)]	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0
5.2 Wave pressure[4)]	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0
5.3 Hydrodynamic effect[4)]	-	-	-	-	-	-	1.0/0
For Notes see Table 6-2.							

Table 6-4 Load Combinations for ULS-STR for Foundations (Structural NOT Geotechnical)

Load Combination	Combination 1				Combination 2				Seismic	Acc.
	B1a (CLL)	B2a (W)	B1b (CLL)	B2b (W + CLL)	B1a (CLL)	B2a (W)	B1b (CLL)	B2b (W+CLL)	S1 2) (EQ)	A1 (BI)
1. Permanent Loads										
1.1 Dead load (DL), Superimposed Dead Load (except surfacing) (SIDL) and Backfill	1.35	1.35	1.35	1.35	1.0	1.0	1.0	1.0	1.35	1.0
1.2 Surfacing	1.75	1.75	1.75	1.75	1.0	1.0	1.0	1.0	1.75	1.0
1.3 Prestress (primary and secondary effects) (P) [1]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.4 Settlement effects[4]	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0
1.5 Earth pressure due to backfill[4]	1.5/1.0	1.5/1.0	1.5/1.0	1.5/1.0	1.3/0.85	1.3/0.85	1.3/0.85	1.3/0.85	0/1.0	0/1.0
2. Variable Loads [6]										
2.1 Carriageway Live Loads (CLL) Vehicular Live Loads [8] [15], Braking [14]	1.5	-	1.5	1.15	1.3	-	1.3	1.00	0.2	0.2
2.2 Thermal Actions (Uniform & Gradient)(accomp.)	0.9	-	-	-	0.8	-	-	-	0.5	0.5
2.3 Wind load (W) [13]	-	1.5	0.9	1.5	-	1.3	0.8	1.3	-	-
2.4 Live load surcharge (accompanying load) [4]	1.2/0	1.2/0	1.2/0	1.2/0	1.0/0	1.0/0	1.0/0	1.0/0	0.2/0	0.2/0
3. Accidental Effects [9]										
3.1 Barge impact (BI)	-	-	-	-	-	-	-	-	-	1.0
4. Seismic effect (EQ)										



	a) during service	-	-	-	-	-	-	-	-	1.5	-
5.	**Hydraulic Loads** (accompanying load)										
5.1	Water current force[4)]	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	-
5.2	Wave pressure[4)]	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	-
5.3	Hydrodynamic effect[4)]	-	-	-	-	-	-	-	-	1.0/0	-
For Notes see Table 6-2.											

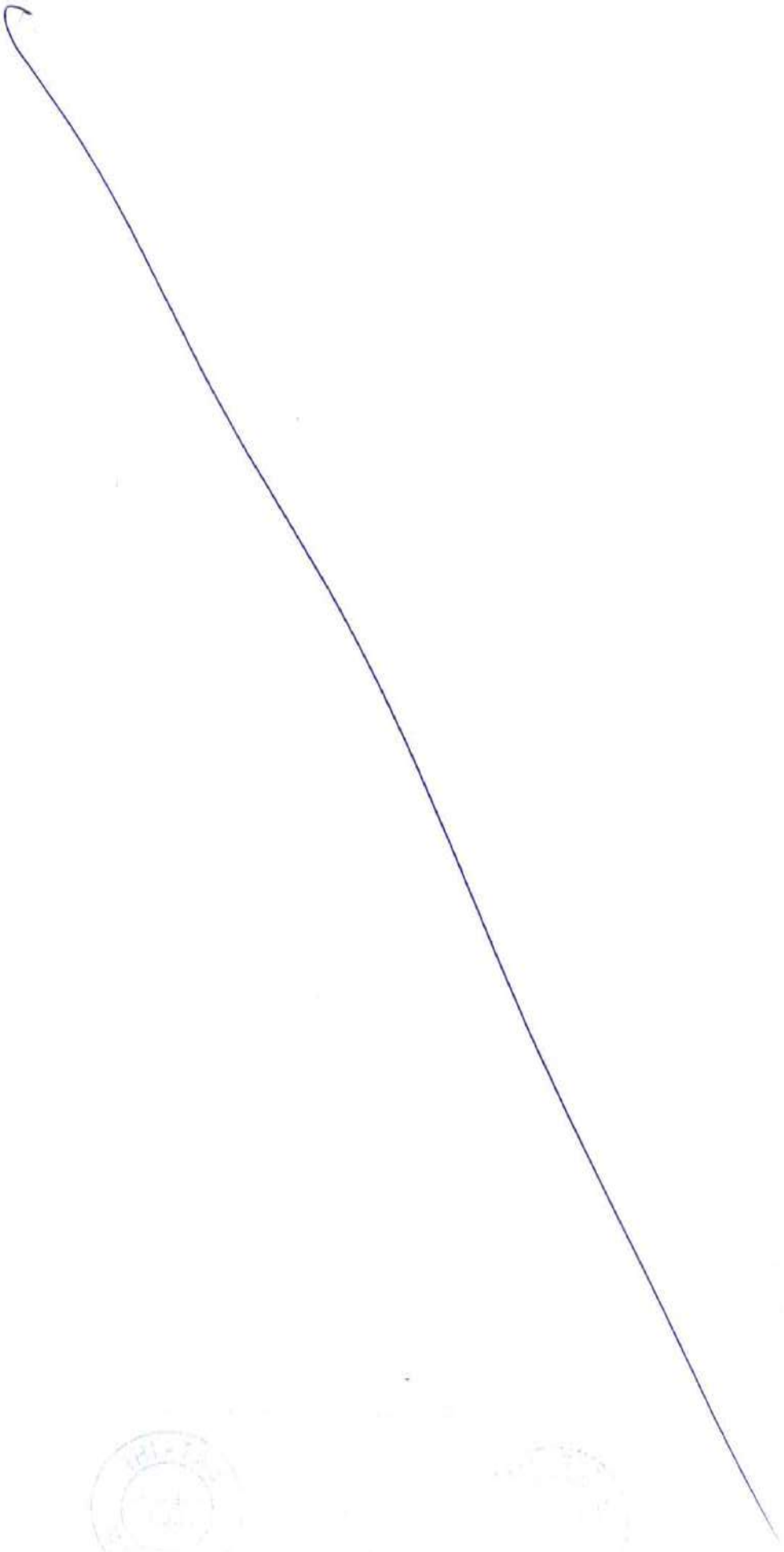


6.2 BEARING CAPACITY OF PILES

The load combinations for determining the bearing capacity of piles used for Tender Design are in accordance with IRC:78-2014, §706.1 and are presented in Table 6-5.

Table 6-5 Load Combinations for bearing capacity of piles

Combination SLS Pile Verification		B1	B2 (W)	S1 [2] (EQ)	A1 (BI)
1. Permanent Actions					
1.1 Self weight DL		1.00	1.00	1.00	1.00
1.2 SIDL excluding surfacing		1.00	1.00	1.00	1.00
1.3 Surfacing		1.00	1.00	1.00	1.00
1.4 Backfill weight, (soil over pile cap, if any)		1.00	1.00	1.00	1.00
1.5 Prestress internal bonded/external unbonded tendons(primary & secondary effect)		1.00	1.00	1.00	1.00
1.6 Creep & shrinkage effect		1.00	1.00	1.00	1.00
1.7 Settlement[4] effects		1.00	1.00	1.00	1.00
1.8 Hydrostatic force (weight of water, if relevant)		1.00	1.00	1.00	1.00
2. Variable Actions					
2.1 Carriageway traffic action and associated actions [braking, tractive & centrifugal forces]		1.00	1.00	1.00	1.00
2.2 Bearing Friction Force		1.00	1.00	1.00	1.00
4. Wind Action	No Traffic ($WL_{Unloaded}$)	-	-	-	-
	With Traffic (WL_{Loaded})	-	1.00	-	-
5. Hydraulic Actions					
5.1 Water current action		1.00	1.00	1.00	1.00
6. Seismic Actions					
6.1 Hydrodynamic action		-	-	1.00	-
6.2 Seismic action effect		-	-	1.00	-



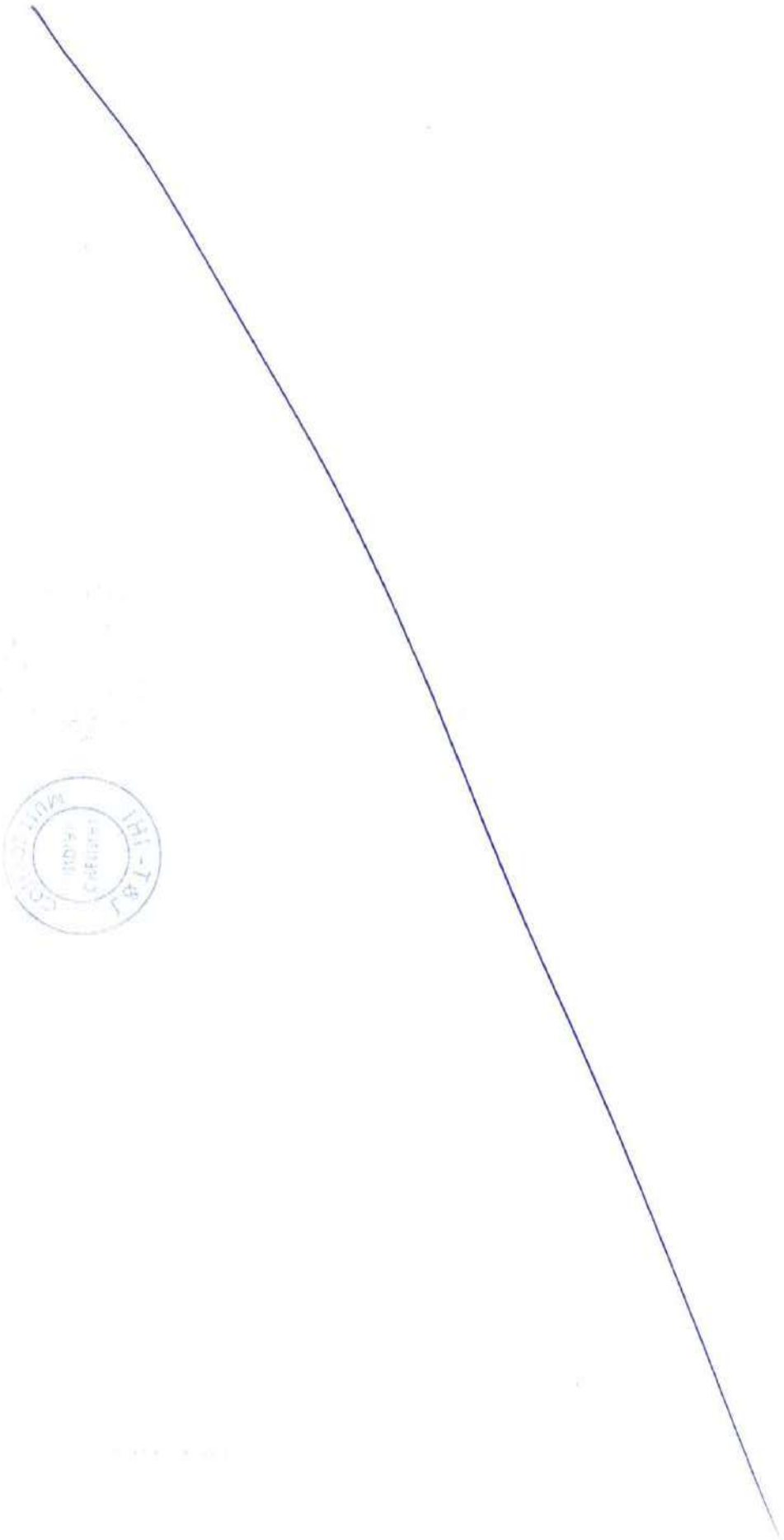
7. Accidental Actions				
7.1 Barge Impact (BI)	-	-	-	1.00

For Notes see Table 6-1.

6.3 STEEL STRUCTURES

The load combinations for allowable stresses for steel structures for use in Tender Design shall in accordance IRC:-2017, Table 1, (reproduced below as **Error! Reference source not found.**).

1	2	3	4	5	6	7	8	9	10			11	12	13	14	15	16	17	18	19	20	21	22
	G	Q	G_s	Q_{im}	F_{im}	V_c	W	F_{wc}	(F_a or F_b) & /or F_f			F_{cf}	G_b	F_{ep}	F_{te}	F_d	F_s	F_{er}	F_{eq}	F_{wp}	G_e	%	
	Dead Load (G)	Live Load (Q)	Snow Load (G_s)	Vehicle Impact (Q_{im})	Impact Floating Bodies (F_{im})	Vehicle Collision Load (V_c)	Wind (W)	Water Current (F_{wc})	Tractive (F_a)	Braking (F_b)	Bearing Friction (F_f)	Centrifugal Force (F_{cf})	Buyoancy (G_b)	Earth Pressure (F_{ep})	Temperature (F_{te})	Deformation Effects (F_d)	Secondry effects (Fs)	Erection Effects (F_{er})	Seismic (F_{eq})	Wave Pressure (F_{wp})	Grade Effect (G_e)	Permissible Stresses (%)	Remarks
I	1	1	*	1				1	1	1	1	1	1	1							1	100	Service Condition
II A	1	1	*	1				1	1	1	1	1	1	1	1	1	1				1	115	
II B	1	0.5		1				1	0.5	0.5	1	0.5	1	1	1	1	1				1	115	
III A	1	1	*	1			1	1	1	1	1	1	1	1	1	1	1			1	1	133	
III B	1	0.5		1			1	1	0.5	0.5	1	0.5	1	1	1	1	1			1	1	133	
IV	1	1	*	1			1	1	1	1	1	1	1	1		1	1			1	1	133	
V	1					1																150	
VI	1	0.2		1				1	0.2	0.2	1	0.2	1	1	1	1	1		1	1	1	150	
VII	1	1	*	1	1		1	1	1	1	1	1	1	1	1	1	1				1	133	
VIII	1						1	1			1		1	1				1			1	133	Construction Condition
IX	1							1			1		1	1				1	0.5		1	150	



7 CONCRETE STRUCTURES

7.1 DESIGN CODES

Concrete structures shall conform with IRC:112-2011, unless stated otherwise in this document.

7.2 MATERIALS

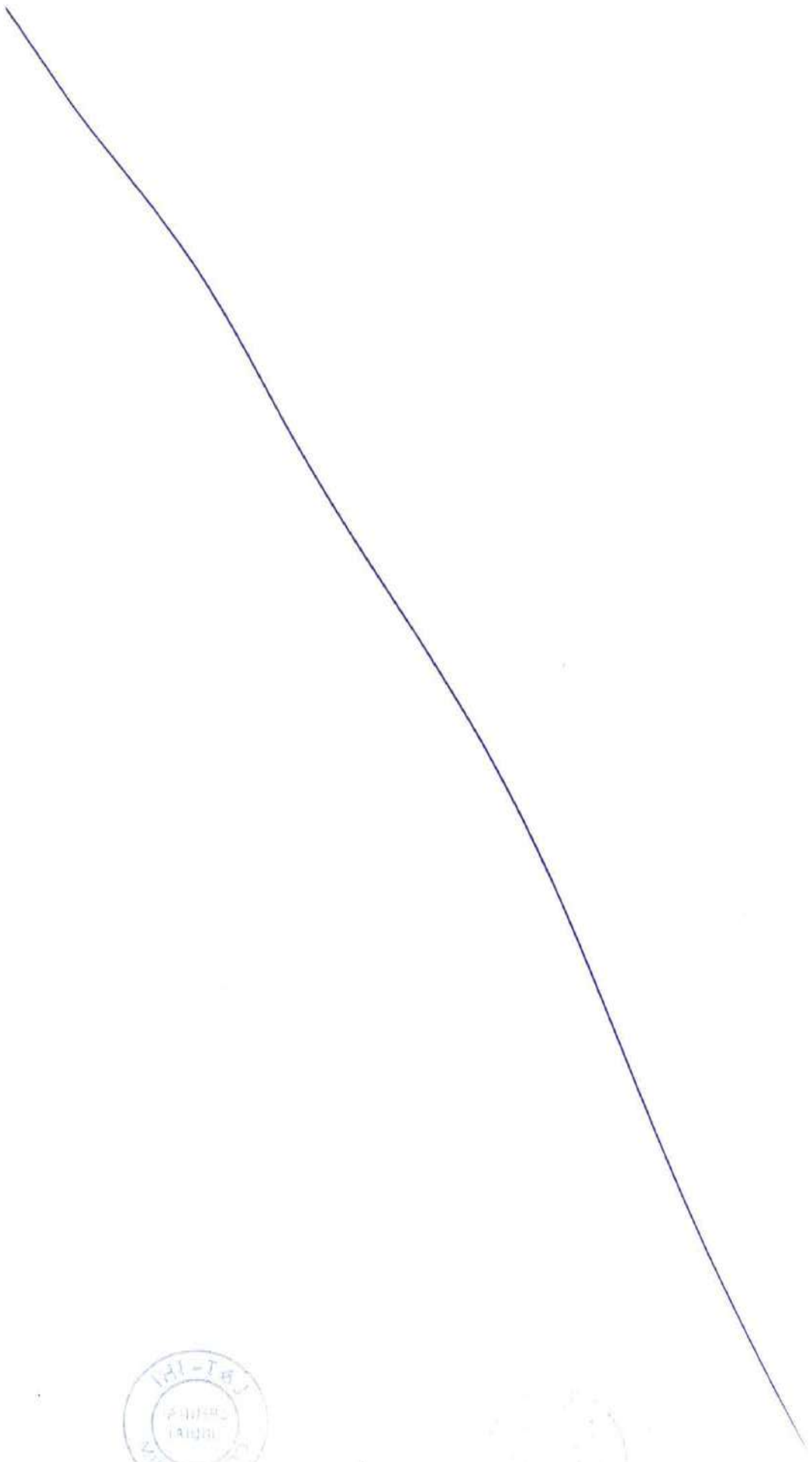
All materials shall conform to IRC:112-2011, IRC:84-1983 and MoRT&H.

Concrete

High performance concrete (HPC) shall be used for all structural concrete members. Minimum concrete grades shall be as stated in Table 7-1.

Table 7-1 Minimum concrete grades

Element	Standard Concrete	High Performance Concrete (HPC)	Characteristic Strength, f_{ck} [1] (MPa)
Blinding	M15	-	15
Bored Piles, Pile Caps	-	M45	45
Piers, Piers heads	-	M55	55



Superstructure	-	M55	55
Parapets	-	M45	45
Note 1. 28 day cube strength in accordance with IRC:112-2011.			

Concrete strength and deformation characteristics of concrete (including HPC) shall be in accordance with IRC:112-2011, Table 6.5.

The maximum aggregate size in all concrete shall be 20 mm.

Reinforcing steel

Carbon steel reinforcement

Carbon steel reinforcement shall be High Yield Strength Deformed Steel (HYSD) of Grade Fe 500D in accordance with IS 1786-2000 and IRC:112-2011, Table 18.1. Reinforcing steel shall not be re-rolled steel.

Type A and Type B couplers may be used for bars larger than 16 mm diameter.

Reinforcement to foundations, pile caps and piers (including couplers, if used) shall have a fusion-bonded epoxy coating confirming with IS 13620-1993.

The following bar sizes shall be used (dia./mm): 10, 12, 16, 20, 25, 32 & 36. The maximum length of single bar considered in design shall be 12 m.

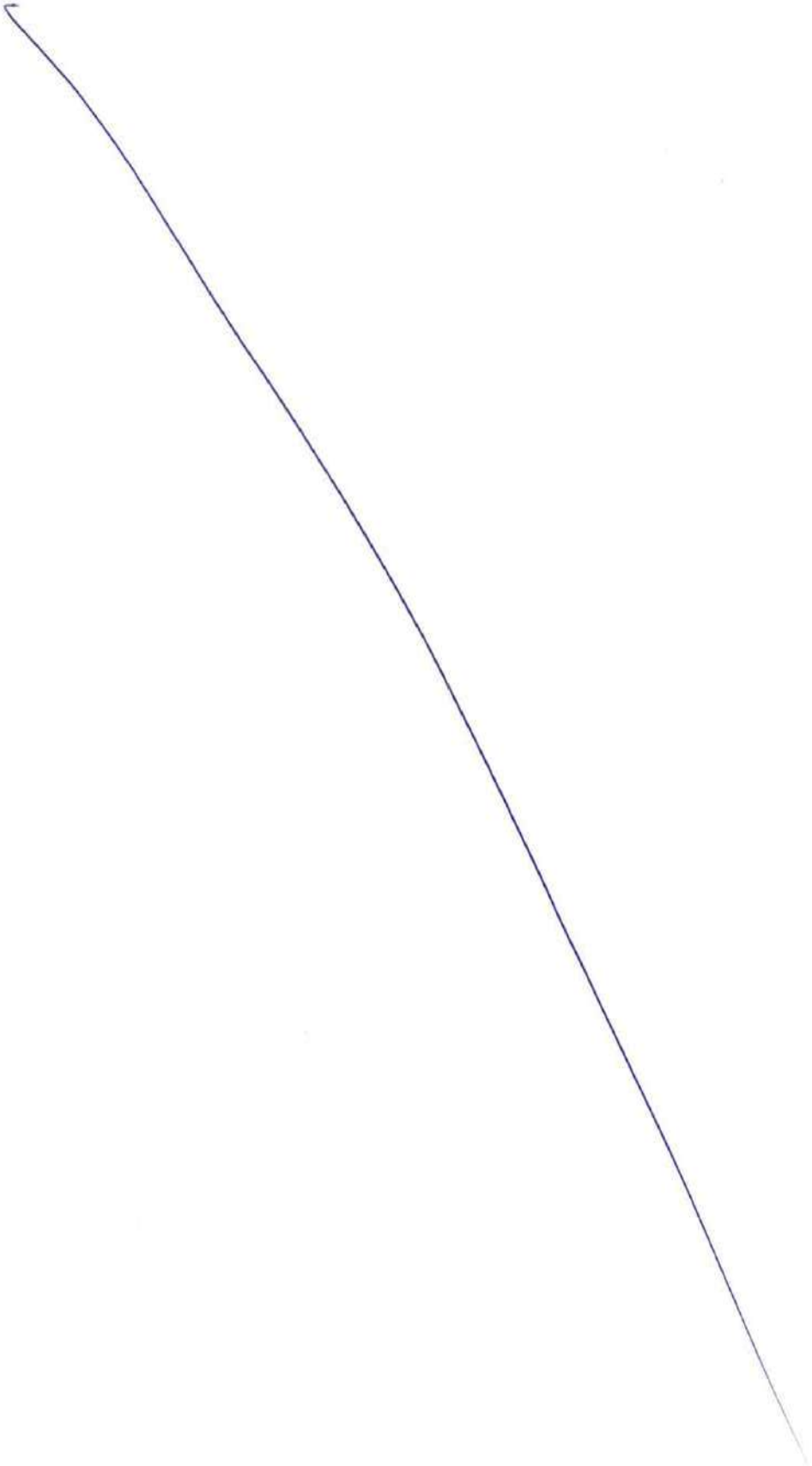
Wire mesh reinforcement shall be galvanized or equivalent.

Pre-stressing steel

Pre-stressing strand

Pre-stressing strand shall be seven-wire low relaxation strand confirming with IRC:112-2011 and IS 14268-1995. The following material properties are assumed for design:

- Nominal diameter = 15.2 mm
- Nominal steel area = 140 mm²
- Tensile strength, f_{pk} = 1860 MPa
- Minimum breaking load, P_n = 260.4 kN



- Initial pre-stressing = 0.75 x f_{pk} (unless noted)
- Elastic modulus = 195,000 MPa

Pre-stressing strand for internal tendons shall be epoxy coated (flow-fill type). Pre-stressing strands for external tendons shall be greased and sheathed.

Pre-stressing bars

Pre-stressing bars shall confirm with prEN 10138-4: 2000, IRC:112-2011 and IS 2090. The following material properties are assumed for design, based on two or more stressing cycles:

- Bar diameters to be used: 40 mm, 50 mm and 75 mm
- Tensile strength, f_{pk} = 980 MPa
- Minimum 0.1% proof stress, $f_{p0.1k}$ = 784
- Minimum elongation = 10%
- Initial pre-stressing = 0.90 x $f_{p0.1k}$ (unless noted)
- Elastic modulus = 170,000 MPa

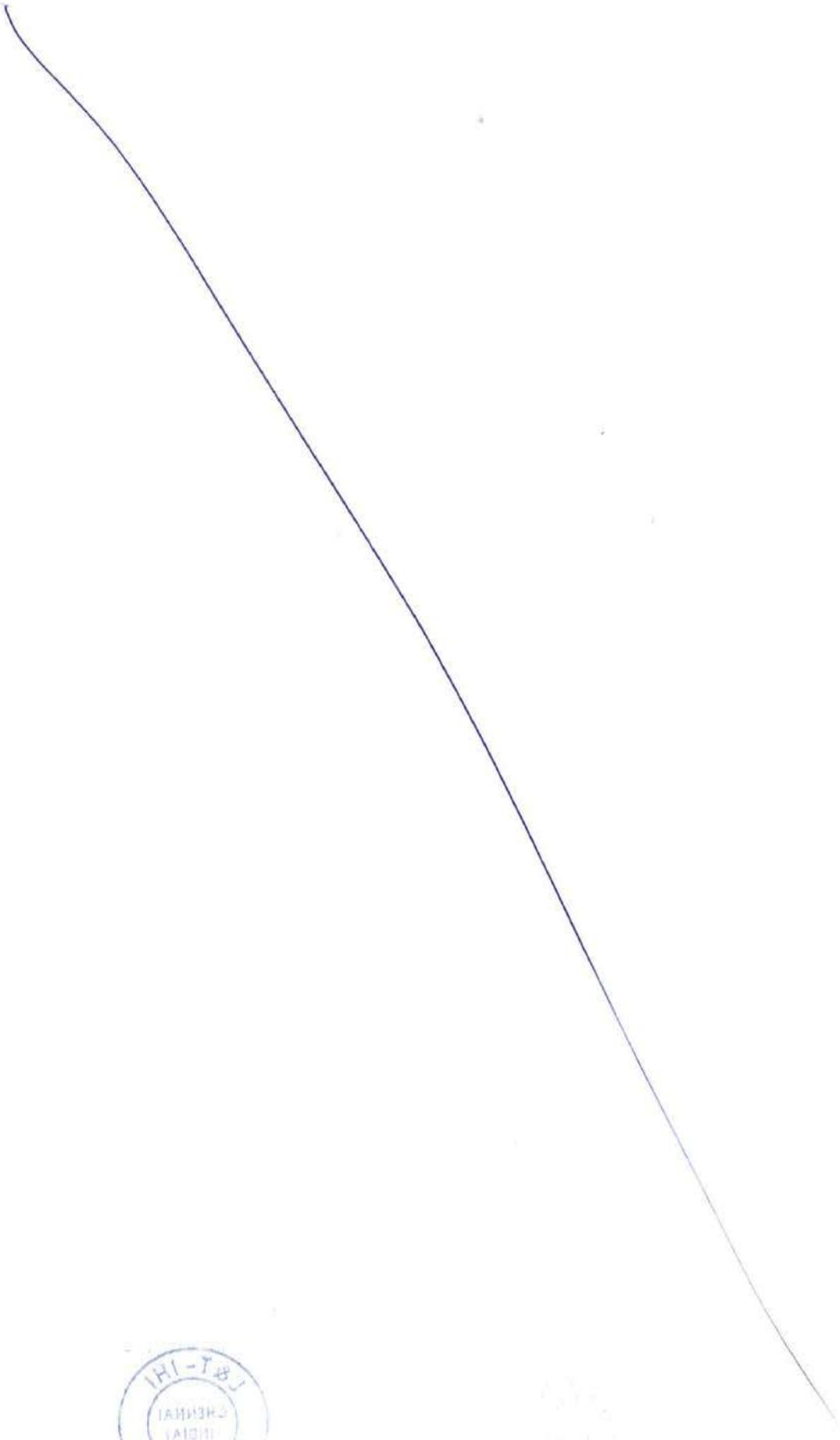
7.3 DURABILITY

Minimum concrete grades shall be in accordance with Table 7-1, above.

Exposure conditions, minimum concrete covers to reinforcement and maximum crack widths for concrete structures shall be in accordance with Table 7-2.

Table 7-2 Minimum concrete covers and maximum crack widths

Element	Level	Exposure Category (IRC)	Minimum Concrete Cover for Durability	Maximum Crack Width	Nominal Concrete Cover for Crack Width Calculation
			(mm)	(mm)	(mm)



Piles	Below level -0.5 m CD	Severe	75	0.3	30
	From level -0.5 to +10.5 m CD	Extreme		0.20	
	From level +10.5 m CD to under-side of pile bent cross head	Very Severe	50		
Pile caps	-	Extreme	75		
Pile bent cross head	From level +10.5 m CD upwards	Very Severe	50		
Pier columns	Below level +10.5 m CD	Extreme	75		
	From level +10.5 m CD upwards	Very Severe	50		
Bridge decks	-	Severe	45	0.3	

Notes. 1. For pre-stressing tendons and bars, the minimum clear cover measure form the outside of the sheathing shall be 75 mm.
2. Wire mesh reinforcement shall be installed at all locations where the actual cover is more than 50 mm.

7.4 PRECAST SEGMENTAL CONSTRUCTION

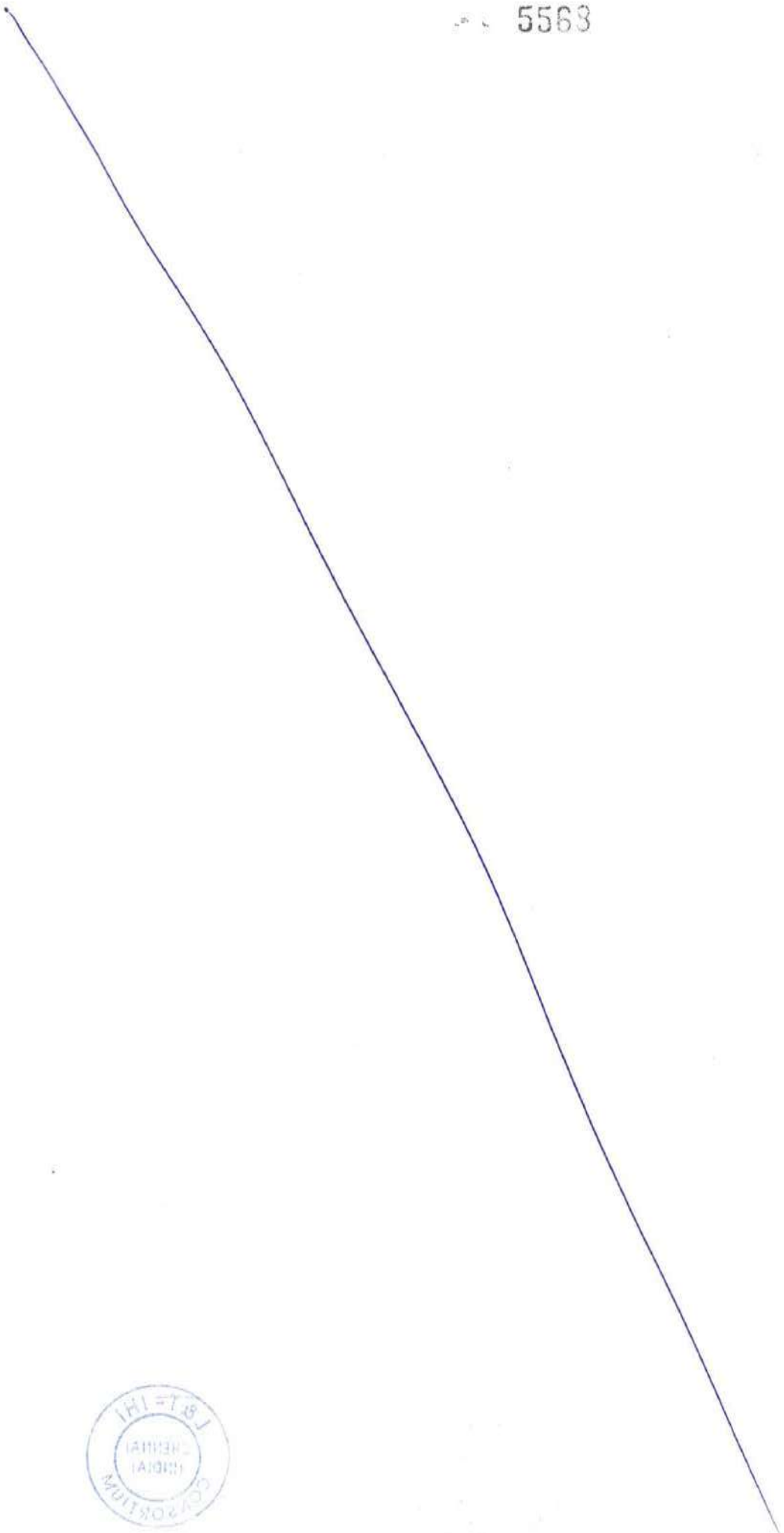
IRC:SP-65-2005 shall be taken into account in the design of precast segmental bridge structures.

7.5 PARTIAL FACTORS FOR MATERIALS (ULS)

Partial factors for materials for ULS shall be as stated in Table 7-3, as per IRC:112-2011.

Table 7-3 Partial factors for materials for ULS

Partial Factor for Material	ULS Load Combination		
	Basic	Seismic	Accidental



Un-tensioned steel reinforcement (γ_s)	1.15	1.15	1.0
Pre-stressing steel (γ_{ps})	1.15	1.15	1.0
Concrete (γ_c)	1.5	1.5	1.2

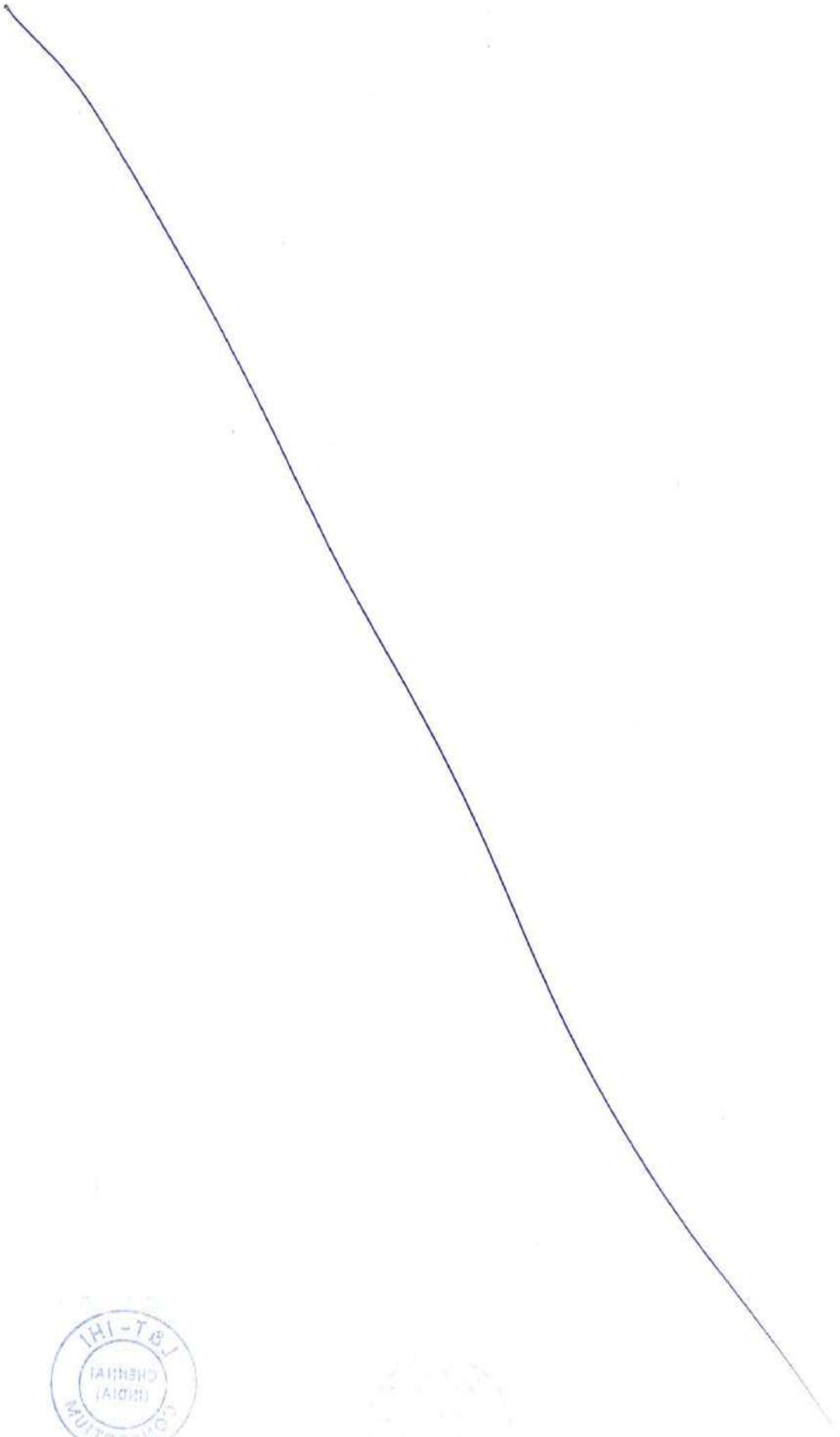
7.6 LIMITING STRESSES (SLS)

The following limiting stresses shall apply for the SLS Rare Load Combination:

- Maximum compressive stress (concrete) = $0.48 \cdot f_{ck}$
- Maximum tensile stress (reinforcement) = $0.8 \cdot f_{yk}$

7.7 SEISMIC DESIGN

For seismic design requirements see §10.



8 STEEL STRUCTURES

8.1 DESIGN CODES

The design of steel box girders shall be in accordance with Japan Road Association 'Specifications for Highway Bridges - Part II - Steel Bridges' (March 2002), unless stated otherwise in this document.

8.2 MATERIALS

All steel material shall conform to Japan Road Association document 'Specifications for Highway Bridges – Part I – Common – Chapter 3 - Materials' (March 2002). All structural steel shall confirm to JIS G 3106 – 'Rolled steel for welded structure'. Material grades for elements of steel box girders shall be in accordance with Table 8-1.

Table 8-1 Steel grades for major box girder elements

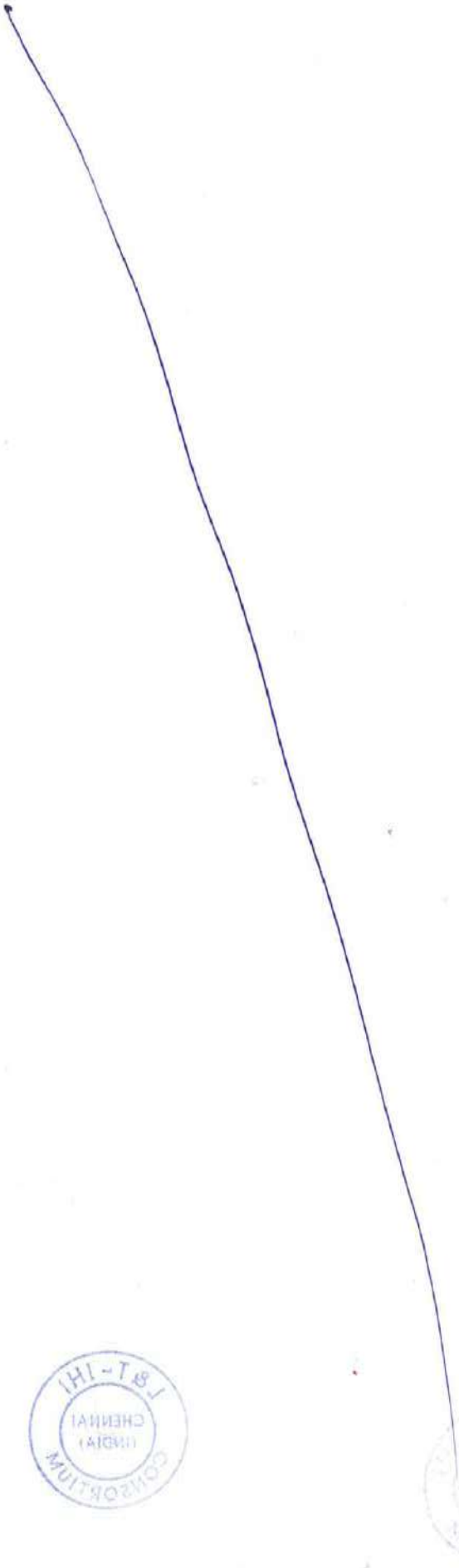
Element		Steel Grade
Longitudinal	Deck plate Bottom flange Webs Longitudinal stiffeners	SM490 [1] / SM570 [1]
Transverse	Horizontal stiffeners Vertical stiffeners	SM400
Filler plates in bolted connections		SS400
Note. 1. Minimum absorption energy 27J in Charpy impact energy test.		

Riveting shall not be permitted.

8.3 FATIGUE

The fatigue design of steel box girders will comply with Japan Road Association 'Guidelines for Fatigue Design of Steel Highway Bridges' (2002).

Fatigue loading shall be in accordance with §5.5, above.



8.4 DURABILITY

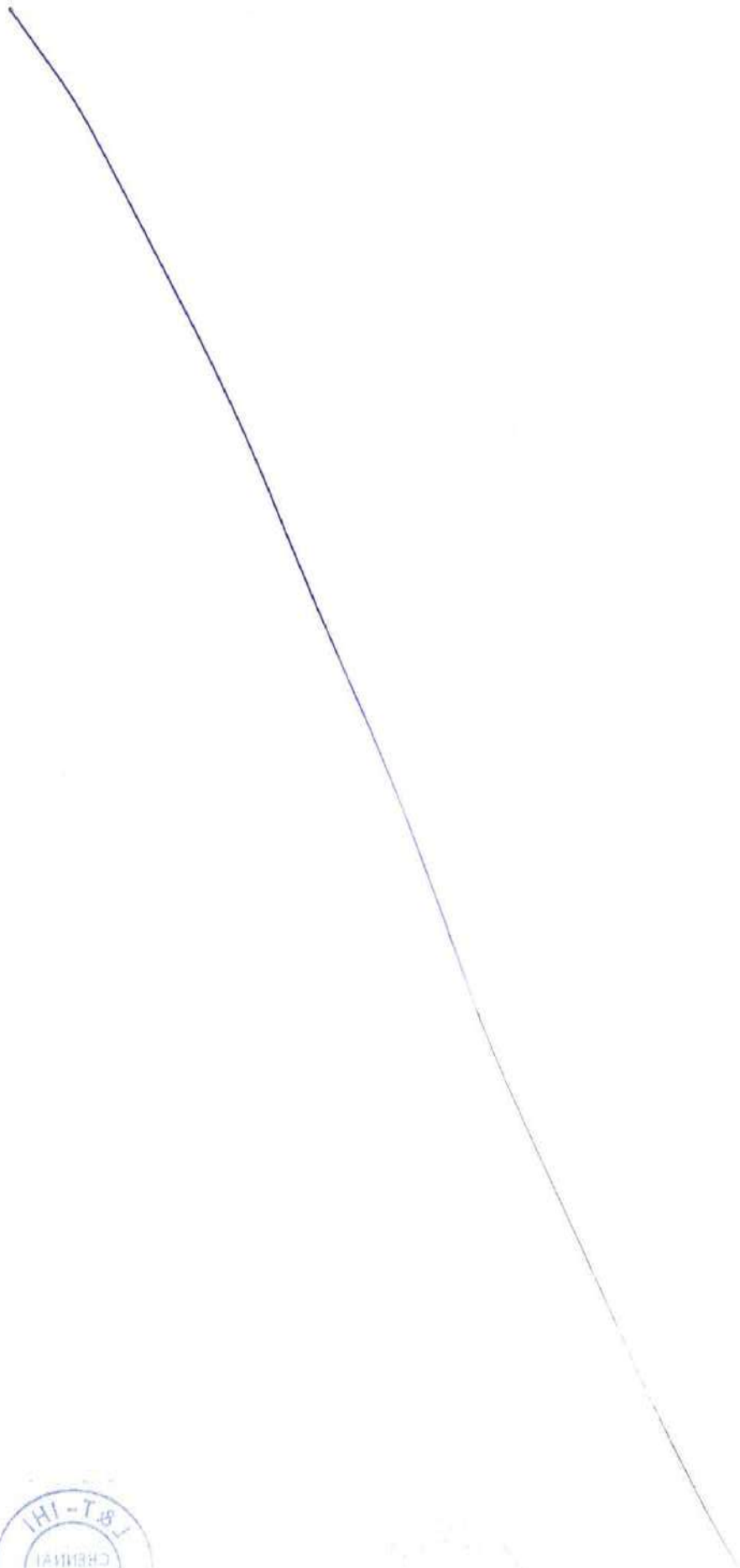
In accordance with the Employer's Requirements, Table 3.8 (ERG-82) and Table 3.9 (ERG-83), protective anti-corrosion coatings to steel box girders shall be as stated in Table 8-2 and Table 8-3

Table 8-2 Anti-corrosion coating (external)

Painting System		Paint Name	Standard Thickness (μm)
Pre-treatment	First base plate conditioning	Primitive plate blasting	-
	Primer	Inorganic zinc primer	(15)
Factory paint	Secondary base plate conditioning	Assembled member blasting	-
	Under coating 1	Inorganic zinc paint	75
	Mist coating	Under coat epoxy resin paint	-
	Under coating 2	Under coat epoxy resin paint	120
	Intermediate coat	Intermediate fluororesin paint	30
	Top coat	Top coat fluororesin paint	25

Table 8-3 Anti-corrosion coating (internal)

Painting System		Paint Name	Standard Thickness (μm)
Pre-treatment	First base plate conditioning	Primitive plate blasting	-
	Primer	Inorganic zinc primer	(15)
Factory paint	Secondary base plate conditioning	Assembled member blasting	-
	Under coating	Modified epoxy resin paint	120
	Top coat	Modified epoxy resin paint	120



Galvanising of secondary steel structures and other components, where required, shall be in accordance with IS 2629 : 1985 and IS 4759 : 1996.

Steel box girder bridge decks shall be provided with an internal de-humidification system.

8.7 SEISMIC DESIGN

For seismic design requirements see §10.

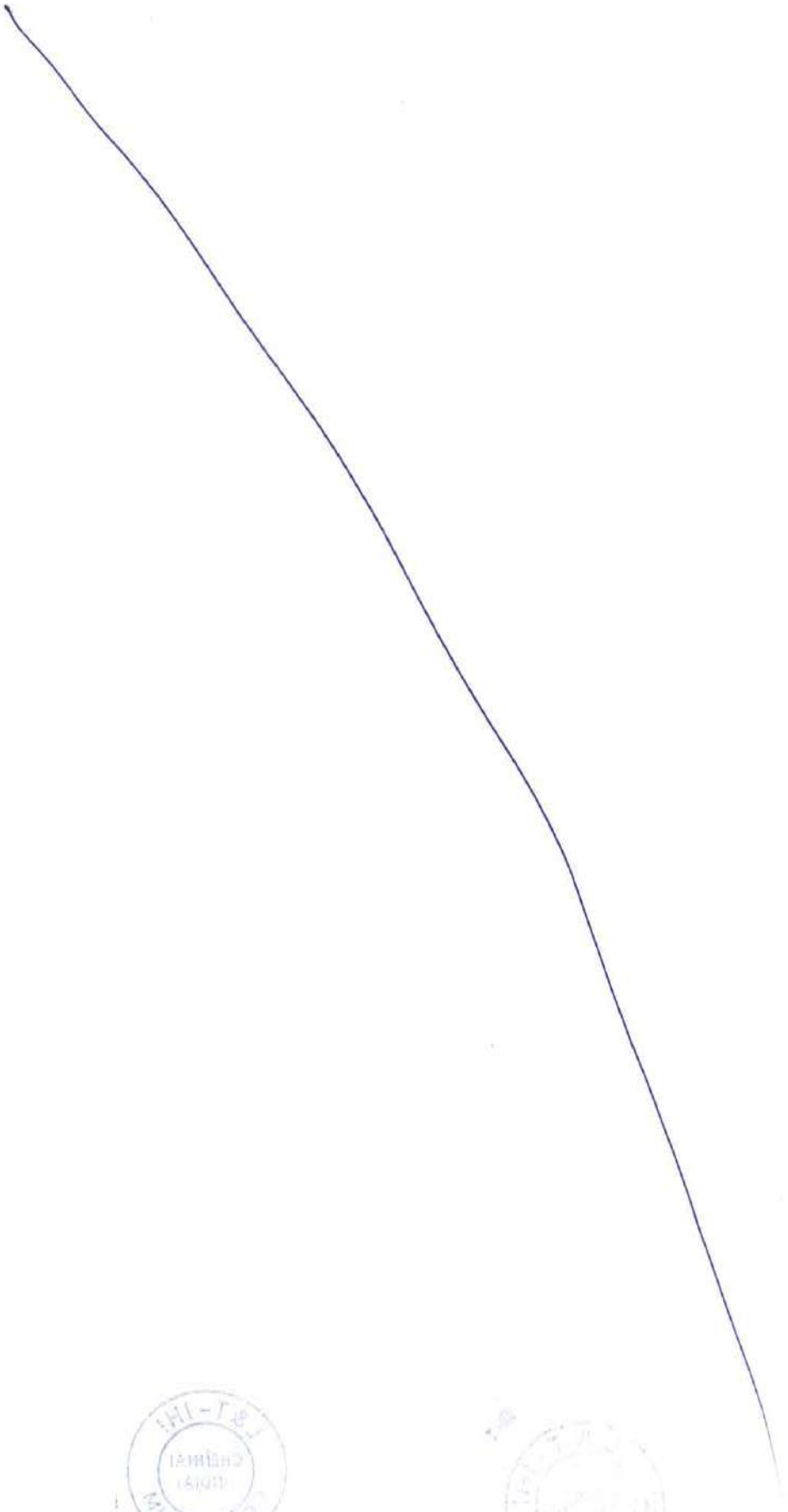
8.8 DEFLECTION LIMITATIONS

For main girders, floor beams and stringers under live loads the deflection calculated using the total cross-sectional area of the member shall not exceed L/500, where L = span length in metres.

Deflection shall be calculated for SLS Frequent load combinations (see Table 6-1, above).

Class 70R and Class A live loads shall include impact and congestion factors.

Special Vehicle (SV) live loading shall not include impact and congestion factors.



9 GEOTECHNICS AND FOUNDATIONS

9.1 GROUND CONDITIONS

The ground conditions and derived soil parameters used for the Tender Design are described in COWI report 'Mumbai Trans Harbour Link – Package 1. Geotechnical Interpretative Report' (ref. A088600-2-05) and are summarised as follows.

The western part of the alignment of MTHL Package 1 is situated partially on land, at about level +5 m CD (chart datum), and partially in a flat tidal area. Towards the east, the alignment progresses seawards into the Thane Creek through shallow mangroves and into slightly deeper sea, reaching a maximum depth at around level -6 m CD.

Surficial Deposits

The surficial deposits consist of very soft marine clay which grades downwards into very stiff to hard marine clay. The clay superposes medium dense to very dense, marine, silty sand with occasional shell fragments. Locally marine sand is not present. The thickness of the superficial deposits varies along the main part of the alignment from less than 5 m CD to 21 m CD.

Unit I

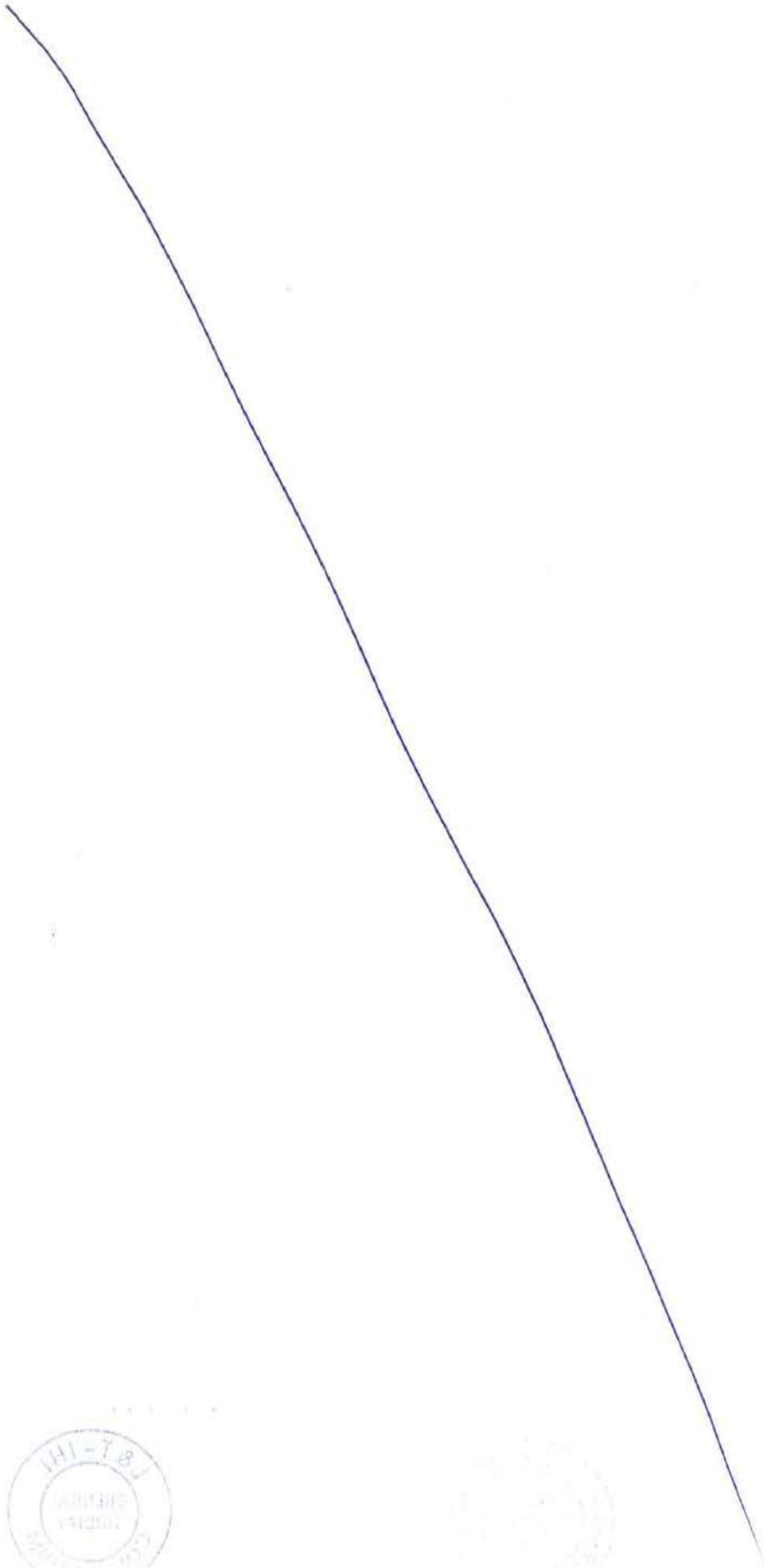
There is a thin layer (up to 3.4 m depth) of filled soil above subsoil in land boreholes drilled at Sewri side (from BH-1 to BH-33), up to an elevation varying between -0.18 m CD (BH-3) and -2.25 m CD (BH-19). This stratum consists of clay mixed with yellow silt & sand in varying percentage.

Unit II

A very soft to stiff clay layer appears at the seabed in tidal and marine parts, and is encountered below the filled soil at the land part with a maximum thickness recorded of around 18.2 m and an average thickness of 8.5 m along the stretch. The bottom of this unit is at an elevation varying between +1.04 m CD (BH-63) to -23.15 m CD (BH-129). This stratum consists of clay mixed with silt and a very low percentage of sand.

Unit III

Below the soft Clay layer, medium dense to dense silty Sand is locally encountered at some boreholes (i.e. from BH-42 to BH-48, from BH-101 to BH-117, etc.). This stratum has a maximum thickness of 10.2 m and 3 m in average where it is present. The bottom of this is at an elevation varying between -0.9 m CD (BH-62) to -23.3 m CD (BH-145).



Basalt rock substrata underlie the marine deposits. On top of the substrata, a layer of very dense, residual soil covers the basalt. Locally, residual soil is missing and weak, highly weathered basalt underlies very dense sand. The upper part of the basalt is in general weak to moderately strong, grading down into strong, slightly weathered, basalt. Occasionally the basalt is very closely fractured with hydrothermal alteration in its upper parts. Locally the basalt is widely to moderately jointed and fractured.

Unit IV

Completely weathered Rock underlies Unit II or Unit III. The bottom of this stratum is at an elevation varying between -2.9 m CD (BH-62) to -29.72 m CD (BH-122). This stratum has a maximum thickness of 19.5 m and 5.4 m in average. Only small pieces of this stratum could be recovered during drilling. The representative uniaxial compression strength for rock unit IV is normally below 1 MPa, with a high spread in the performed sample tests.

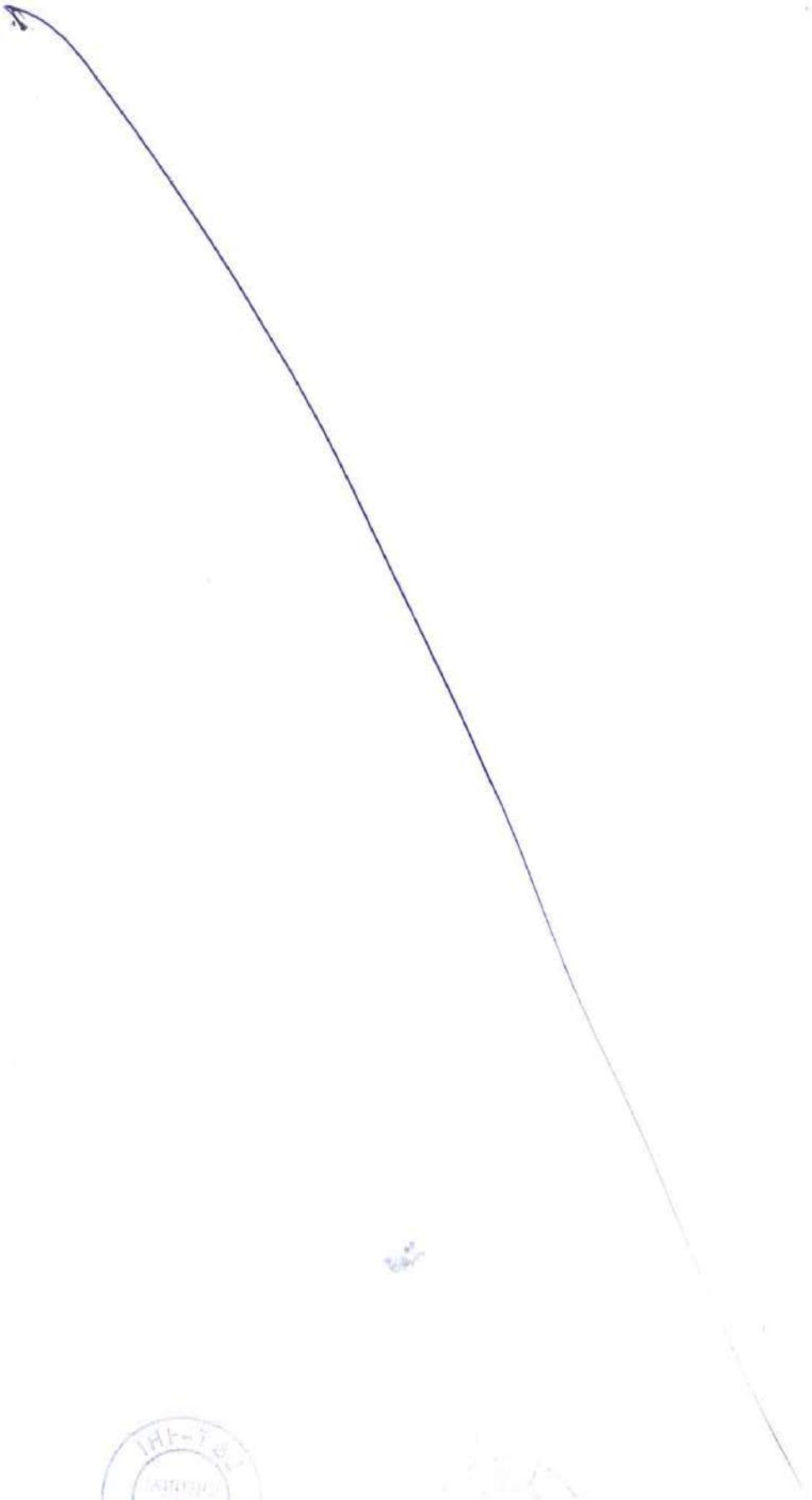
Unit V

Below the completely weathered Rock, highly weathered Rock is encountered. This stratum consists of Igneous rocks which are formed through cooling and solidification of magma/lava, and the reported core recovery values are 0 to 50 percent. The bottom of the highly weathered rock is located at an elevation varying between -9.2 m CD (BH-66) to -43.77 m CD (BH-90). This stratum has a maximum thickness of 16 m and 5.3 m in average. The representative uniaxial compression strength for rock unit V is between 1.5-3.5 MPa, with a high spread in the performed sample tests.

Unit VI

The boreholes have been terminated in moderately to slightly weathered Basalt. Reported core recovery values are 50 to 100 percent, and fair to good state of fractures are reported. The representative uniaxial compression strength for rock unit VI is between 30-35 MPa.

An overview of subsoil profiles and soil/rock properties on the MTHL alignment is presented in Appendix B.



9.2 PILED FOUNDATIONS

General

Piled foundations shall be concrete piles designed in accordance with IRC:78-2014, unless stated otherwise in this document.

The following shall not be permitted:

- Mono-pile (single pile) foundations to individual piers
- Raking/sloping/diagonal piles
- Friction piles

Combined footings at individual piers are permitted, provided that the aesthetic guidelines and all other ERs are met.

Load bearing capacity

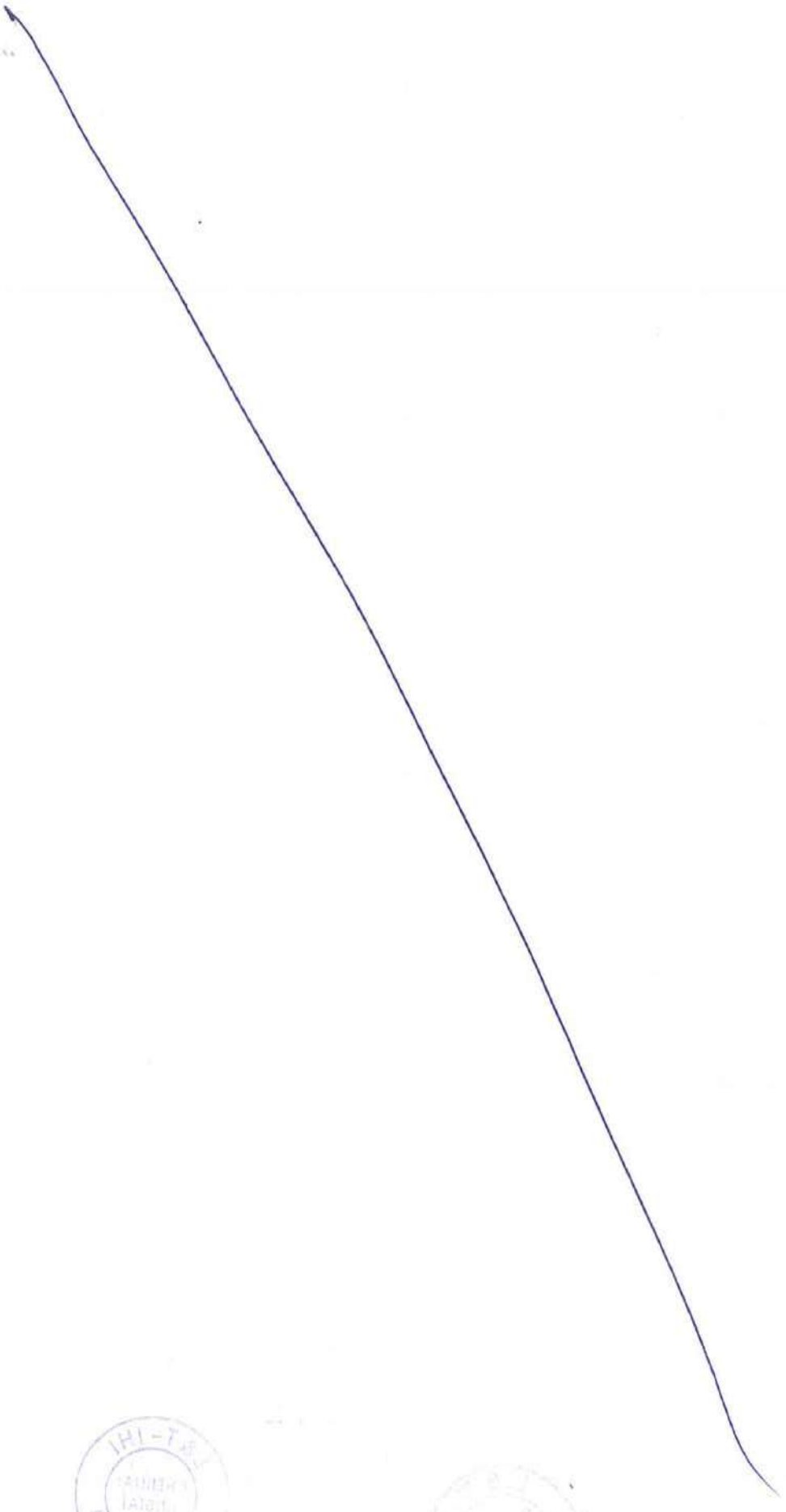
The load bearing capacity of a pile shall be determined using the procedures in IRC:78-2014, Appendix-5.

Pile capacity may be computed considering contributions from bearing friction and friction and end bearing in rock, as per IRC:78.

Friction from overburden soil shall not be considered.

The ultimate shear strength along the socket length shall be restricted to 1.5 MPa.

When piles are terminated in Hard Rock (defined as rock with RQD >60%) the allowable end bearing shall be restricted to 5 MPa as prescribed in IRC:78, whereas if they are terminated in weathered rock (RQD ≤ 60%) the allowable end bearing shall be restricted to 3 MPa.



Accidental loading – barge impact

The analysis and design methodology for barge collision shall follow 'AASHTO Guide Specifications for Vessel Collision Design of Highway Bridges' (2009).

The bridge operational classification shall be Critical/Essential.

Piers and foundations adjacent to navigation channels

The requirements of this section apply to piers and foundations adjacent to:

- Tata Thermal Power Station, Intake and Discharge Channel
- Tata Thermal Power Station, Coal Berth Channel
- Thane Creek

The piers and foundations shall either:

- be designed to resist barge impact forces defined in §0, or
- be provided with a Vessel Impact Protection System that is structurally independent of the pier/foundation and designed to resist the barge impact force defined in §0. In addition, a sacrificial fender system with rub-strips shall be provide along either side of the navigation channel.

Other marine piers and foundations

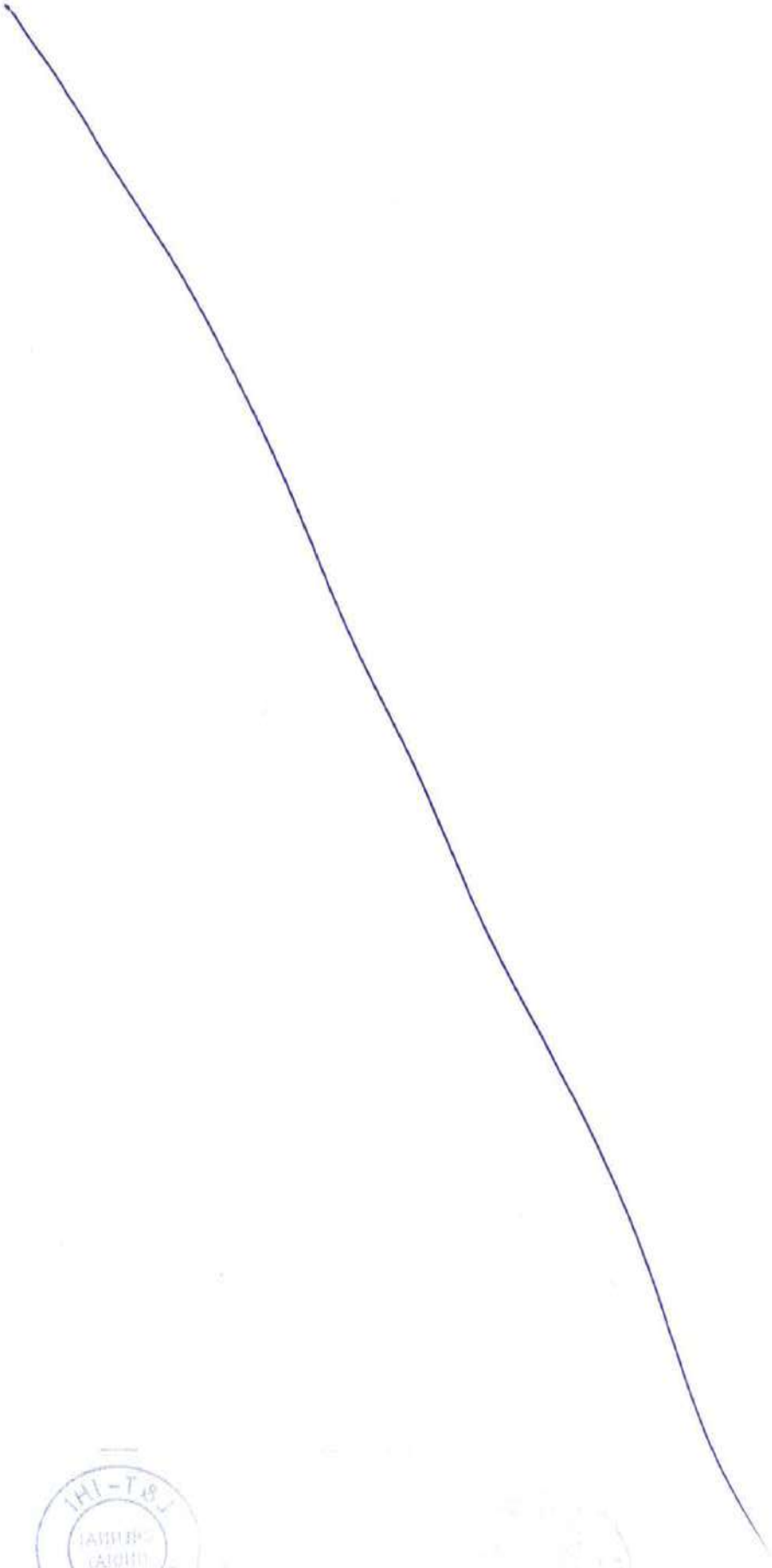
Piers and foundations not adjacent to navigation channels shall be designed to resist the barge impact forces defined in §0.

All those piles to marine piers which are exposed with sufficient freeboard to allow accidental impact from a barge and located in sufficiently deep waters for laden barges as per IRC:6-2017, shall be designed and detailed for protection against all probable structural damages.

Scour

The effects of scour on bridge structures shall be taken into consideration in design.

For Tender Design, any beneficial effects of the upper layer of very soft marine clay (which is susceptible to scour) shall not be considered.



Pile casings

Piles for the marine and land viaducts, bridges and interchanges shall be provided with a permanent full-length non-structural steel casing, in accordance with Table 9-1. The casing shall be terminated at the bottom of the pile cap.

Table 9-1 Thickness of steel casing for piles to marine viaducts and bridges

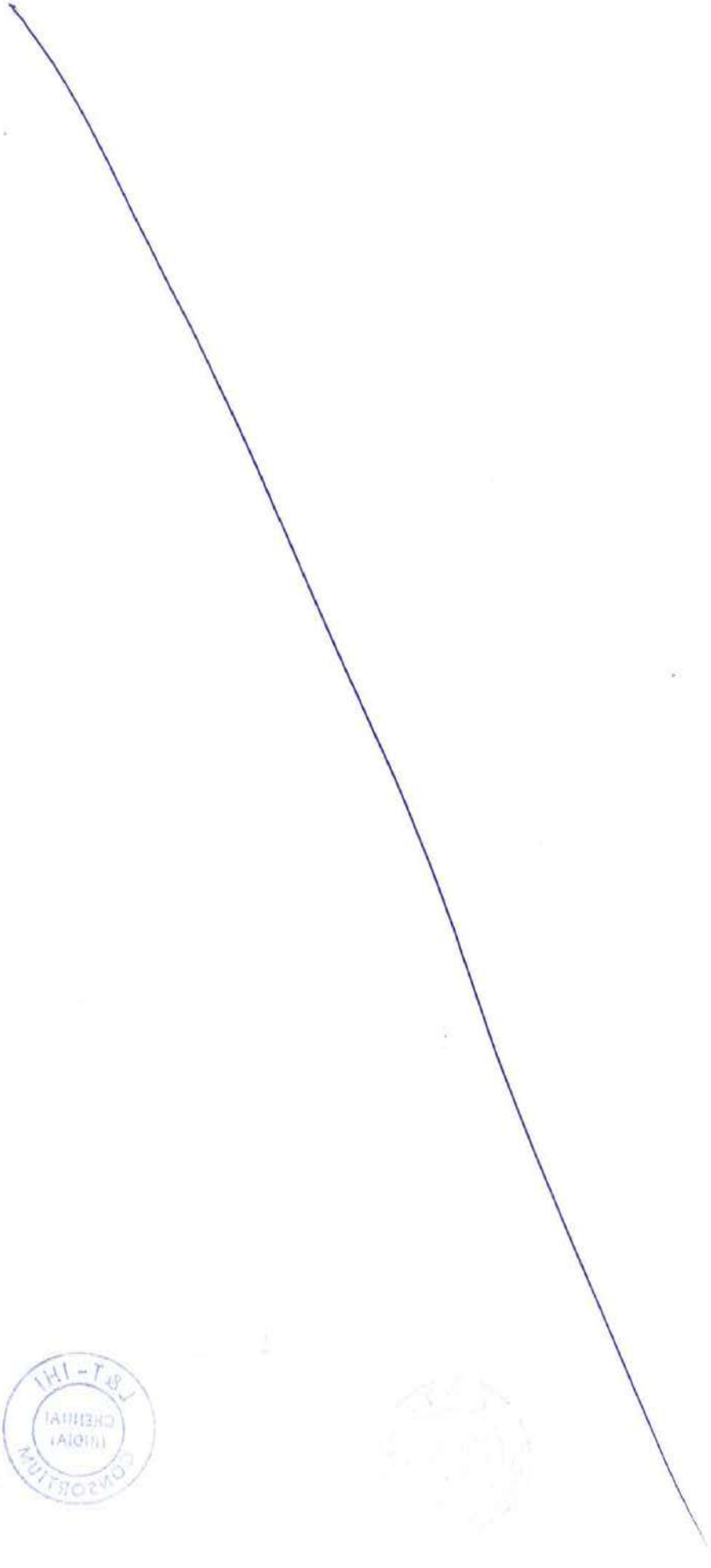
Pile Diameter	Casing Thickness (mm)
Up to and including 1.5 m	8
Greater than 1.5 m and up to and including 2.0 m	12
Greater than 2.0 m	16

9.3 SHALLOW FOUNDATIONS

Shallow foundations designed in accordance with IRC:78-2014, §707.

9.4 SEISMIC DESIGN

For seismic design requirements see §10.



10 SEISMIC DESIGN

10.1 GENERAL

The seismic design shall be in accordance with IRC:6-2014 and IS 1893, unless stated otherwise in this document.

Effective live loads of 20% of design live loads shall be considered while evaluating seismic characteristics and load combinations as per IRC.

Seismic loading shall be determined in accordance with §0, above.

Limit state design shall be used for both OBE and MCE.

Seismic clamps to resist up-lift due to vertical actions shall be installed on or close to the bearings, if necessary.

Anti-dislodgment devices shall be installed on the pier to prevent the superstructure from falling down. The anti-dislodgment devices may be allowed to be damaged, provided that they are repairable.

10.2 OPERATING BASIS EARTHQUAKE (OBE)

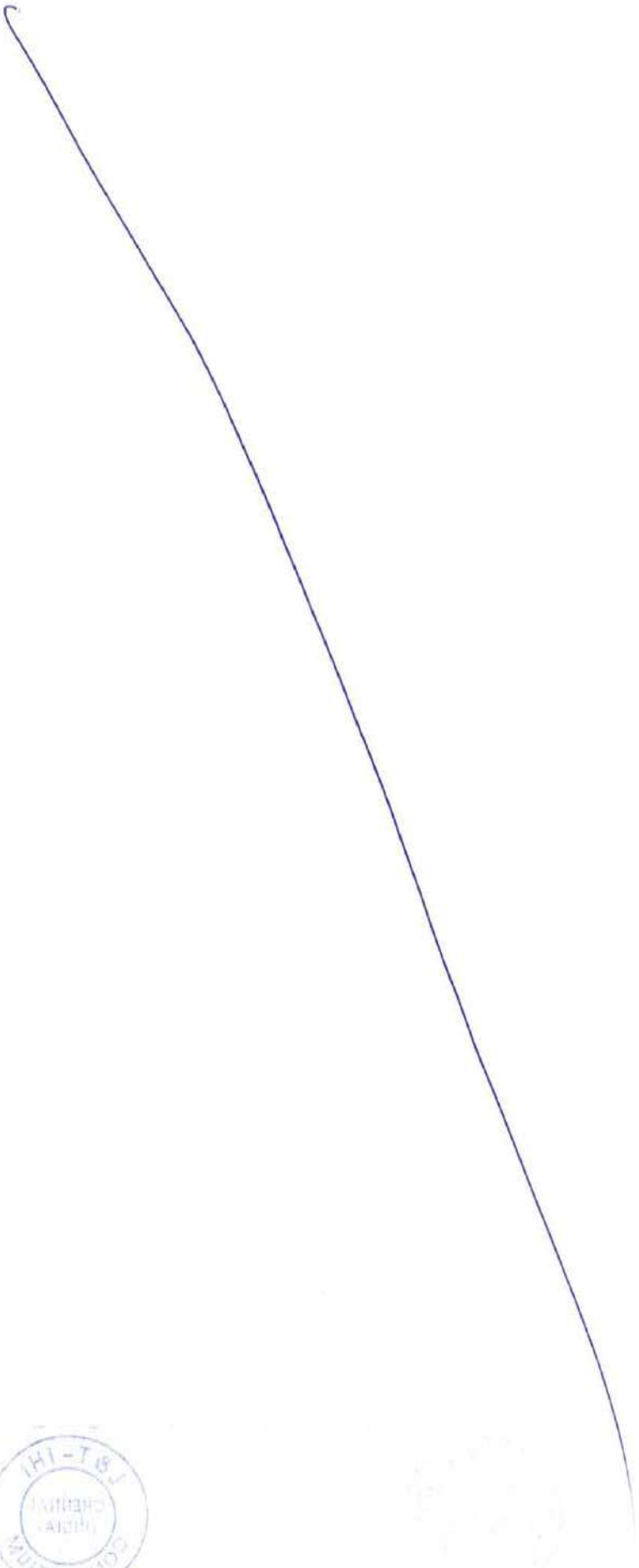
For superstructures using segmental construction where reliance is put on pre-stressing tendon alone at the joints between segments, the maximum stress in the tendon steel shall be in the linear elastic range at all times.

10.3 MAXIMUM CONSIDERED EARTHQUAKE (MCE)

All the main structural components shall remain safe and be repairable, but the secondary components of the bridge including, e.g., safety rails and expansion joints, may be allowed to be damaged but should be replaceable.

When response reduction factors are applied (see 0) ductile reinforcement detailing shall be applied, as described in IRC:6-2014, §219.9.

For superstructures using segmental construction where reliance is put on pre-stressing tendon alone at the joints between segments, the maximum stress in the tendon steel shall be in the linear elastic range at all times.



11 ANCILLARY WORKS

11.1 BEARINGS

General

The bearings shall be capable of transferring loads between the superstructure and the substructure while simultaneously accommodating the articulation of the bridge.

Bearing loads shall be determined from ULS load combinations. Bearing movement shall be determined from SLS Rare load combinations.

The bearings shall be designed to allow their removal and replacement placement with minimal disruption to normal traffic. The bridges shall be designed to permit 20 mm vertical jacking of any bearing without closure of the bridge to road traffic.

The bridges shall be provided with jacking points to allow jacking the structure for bearing replacement.

Elastomeric bearings

Elastomeric bearings to concrete bridges shall conform with IRC:83 (Part II)-2015.

Pot bearings

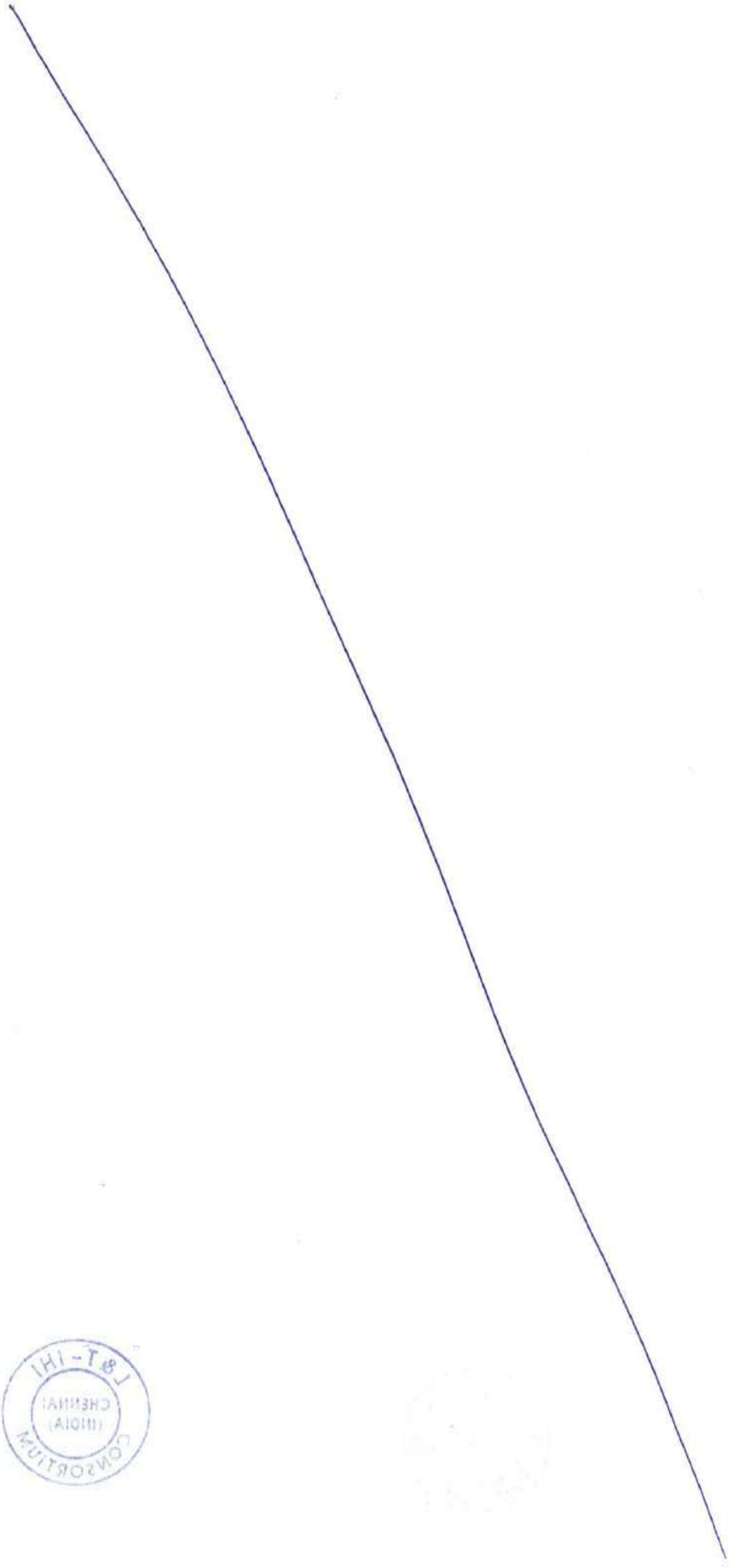
Pot bearings to concrete bridges shall conform with IRC:83 (Part III)-2002, supplemented by AASHTO specifications. Pot bearings to steel bridges shall confirm with Japan Road Association 'Specifications for Highway Bridges' (March 2002).

Spherical bearings

Spherical bearings shall conform with IRC:83 (Part IV)-2014

11.2 EXPANSION JOINTS

Deck expansion joints shall be provided to bridge decks across the movement gaps between adjacent structures.



Longitudinal spacing of expansion joints shall not be less than 200 m for the main bridges of the MTHL.

Expansion joints shall be of the modular type and shall be waterproof.

The design, manufacture testing and installation of expansion joints shall confirm to IRC:SP-69-2011, supplemented by AASHTO specifications.

The expansion joints shall be capable of sustaining traffic loading, including traction, braking and skidding loads, and structural movements (vertical, longitudinal and transverse) due to traffic loads, thermal effects, wind, creep, shrinkage and settlement.

Expansion joints shall not close completely under SLS load combinations.

Expansion joints shall be able to support vertical traffic loading under ULS load combinations.

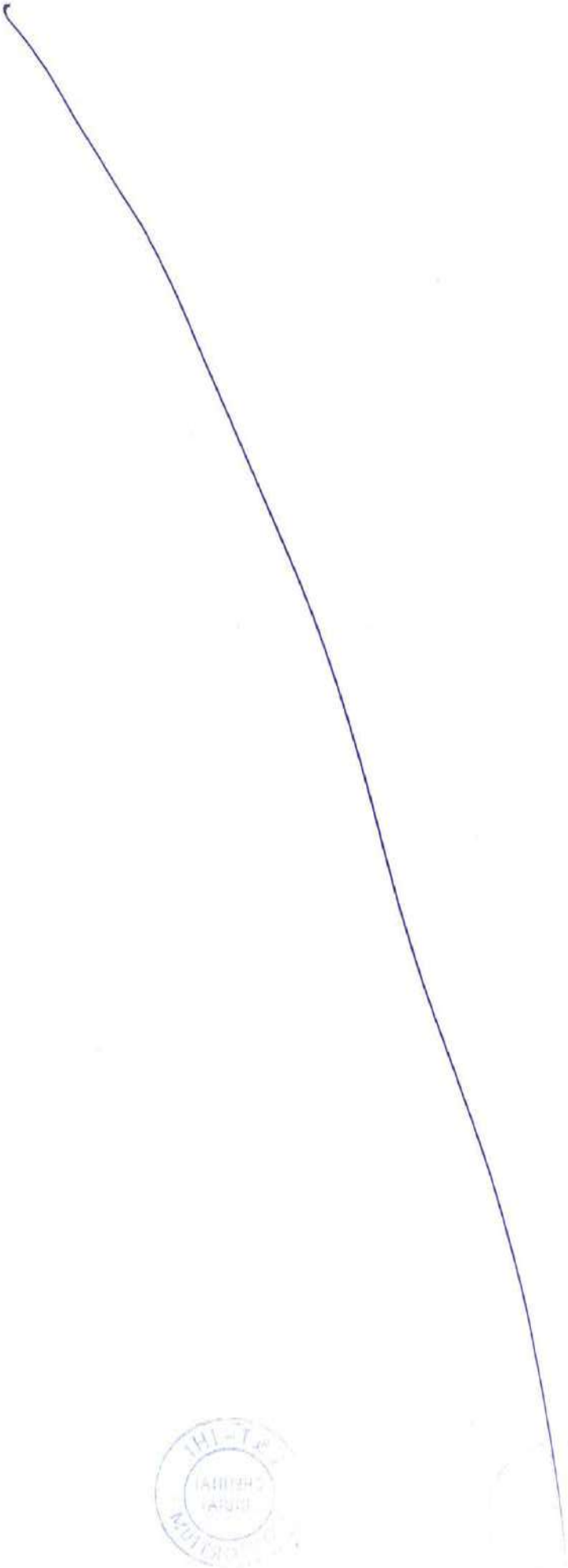
The tops of concrete piers located beneath expansion joints shall be provided with an epoxy waterproofing membrane.

11.3 SURFACING

Bridge deck surfacing shall be in accordance with Table 11-1. A polymer waterproofing membrane shall be provided beneath the surfacing (3mm thick including tack coat).

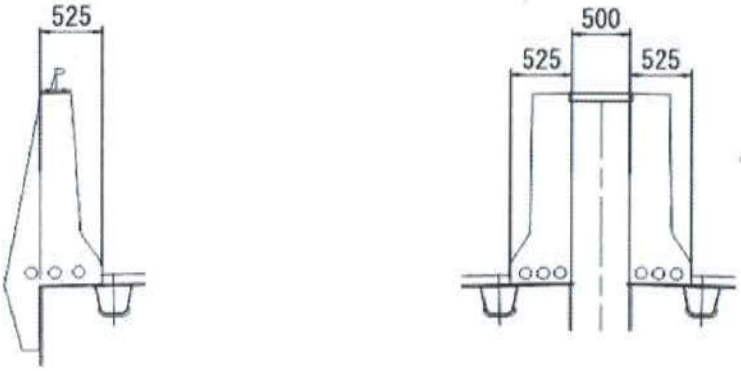
Table 11-1 Bridge deck surfacing

Bridge Deck Type	Layer	Material	Thickness
Concrete	Base course	Stone mastic asphalt	40 mm
	Surface course	Dense graded asphalt	40 mm
Steel	Base course	Stone mastic asphalt	40 mm
	Surface course	Stone mastic asphalt	40 mm



11.4 VEHICLE CRASH BARRIERS

Concrete vehicle crash barriers shall be provided to both sides of the carriageways, as shown in Figure 11-1.

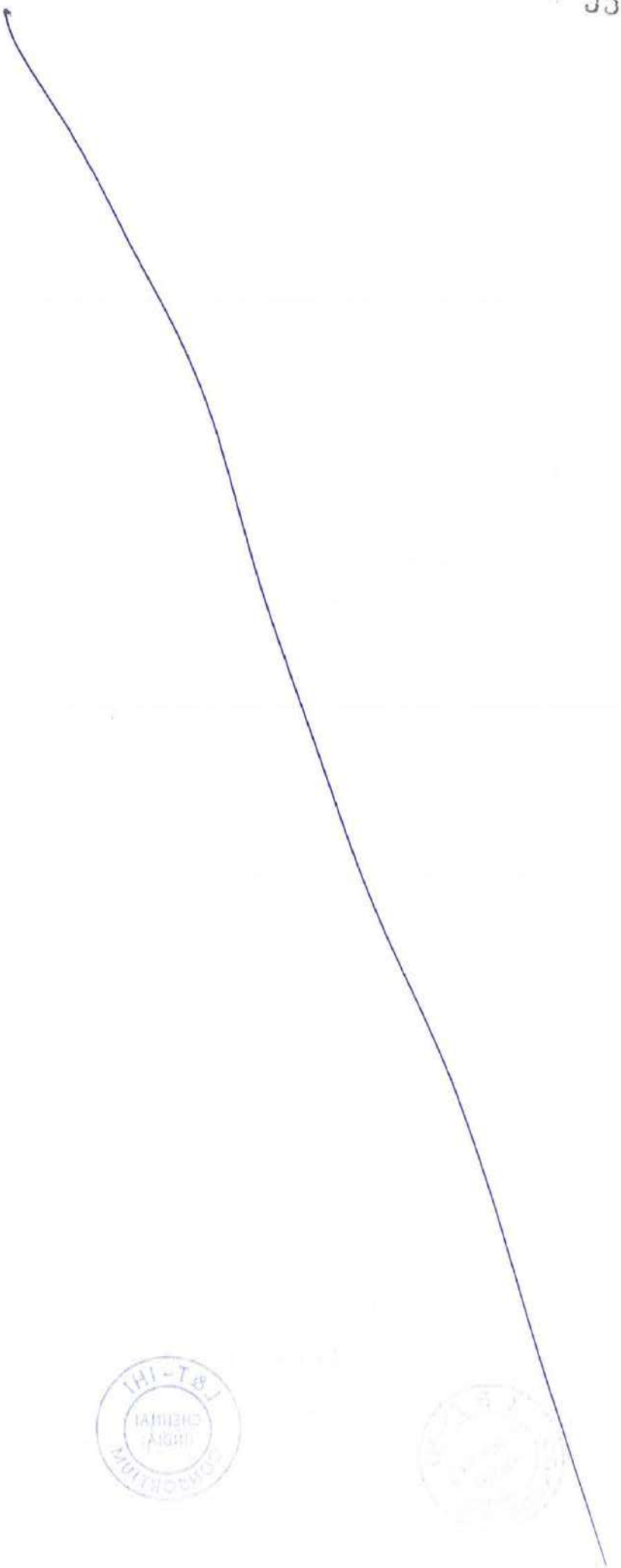


Edge *Median*

Figure 11-1 Locations of vehicle crash barriers for steel bridge deck (ref. MMRDA tender drawing B-054 rev.01). Arrangement for concrete bridge deck deck similar.

The crash barriers shall be of the P-3:High Containment type in accordance with IRC:6-2017, §206.6. The crash barriers shall confirm to IRC:5 1998, §115 and the Employer's Requirements.

Typical crash barrier dimensions are given in Figure 11-2.



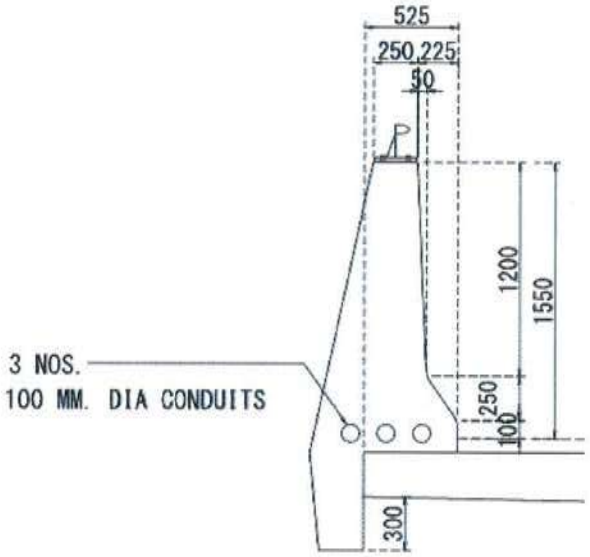


Figure 11-2 Typical dimensions of vehicle crash barrier (ref. MMRDA tender drawing B-054 rev.01).

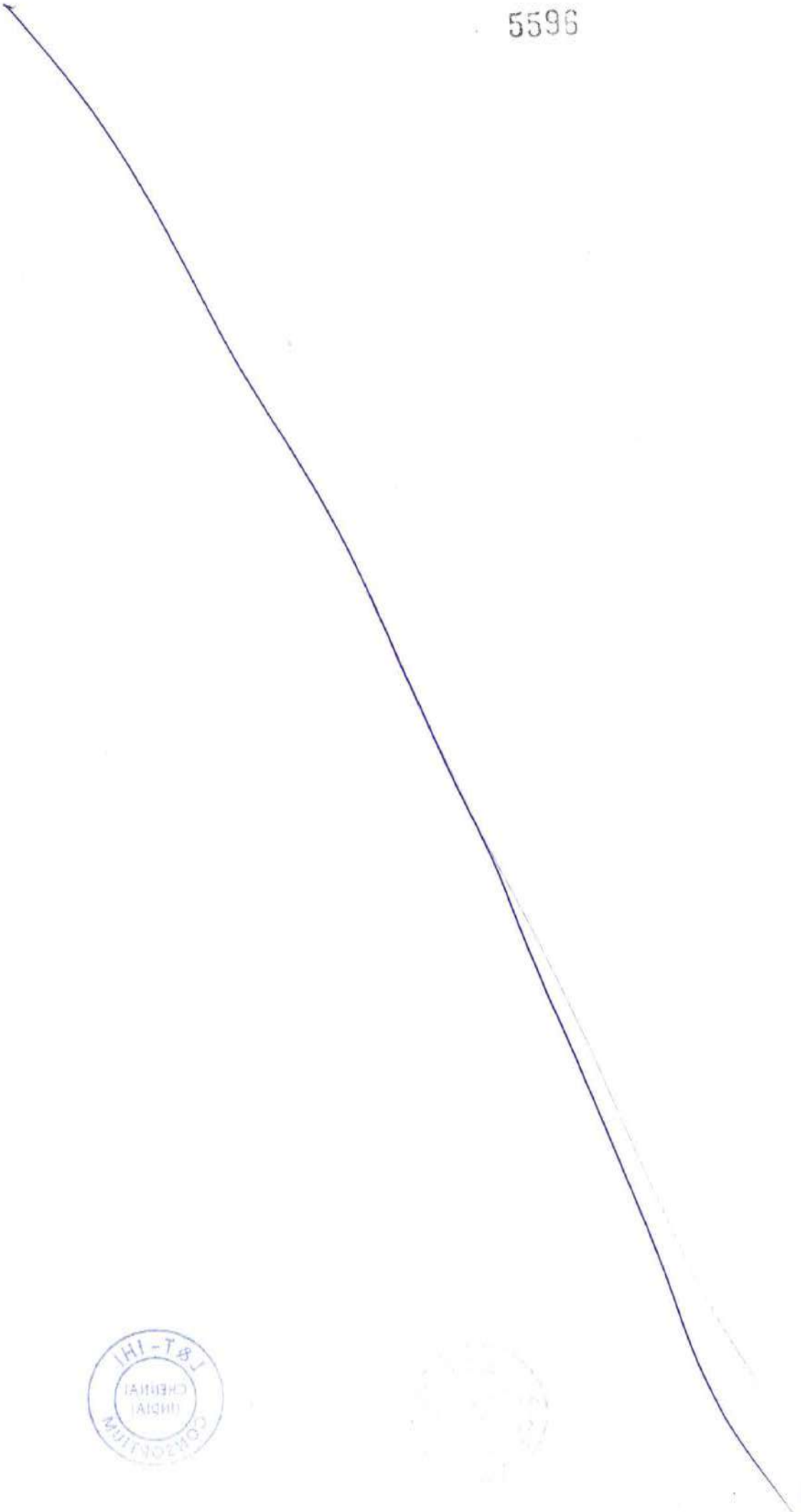
Controlled median openings with removable steel barriers shall be provided at intervals of approximately 2 km along the main bridges of the MTHL and opposite the secondary rescue stations.

11.5 NOISE BARRIERS, VIEW BARRIERS & SAFETY FENCES

Noise barriers, view barriers and safety fences, confirming to §2.9.1, §2.9.2 & §2.9.3, respectively, of the requirements of the Employer's Requirements, shall be provided in the following locations:

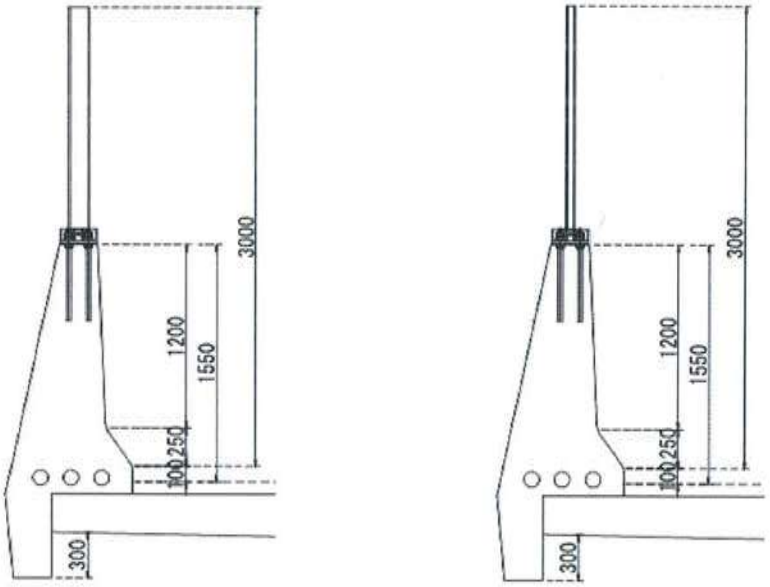
Table 11-2 Locations of noise barriers, view barriers and safety fences

Location		Side of Bridge	Type	Height above Finished Road Level
From	To			
Ch. 0+500	Ch. 4+000	North only	Noise Barrier	3 m
Ch. 4+000	Ch. 10+000	North only	View Barrier	3 m



Ch. 0+500	Ch. 5+500	South only	Noise Barrier	3 m
Ch. 5+5000	Ch. 6+078	South only	Safety Fence	3 m
Ch. 8+720	Ch. 9+080	South only	Safety Fence	3 m

Typical details of noise barriers, view barriers and safety fences are given in Figure 11-3.

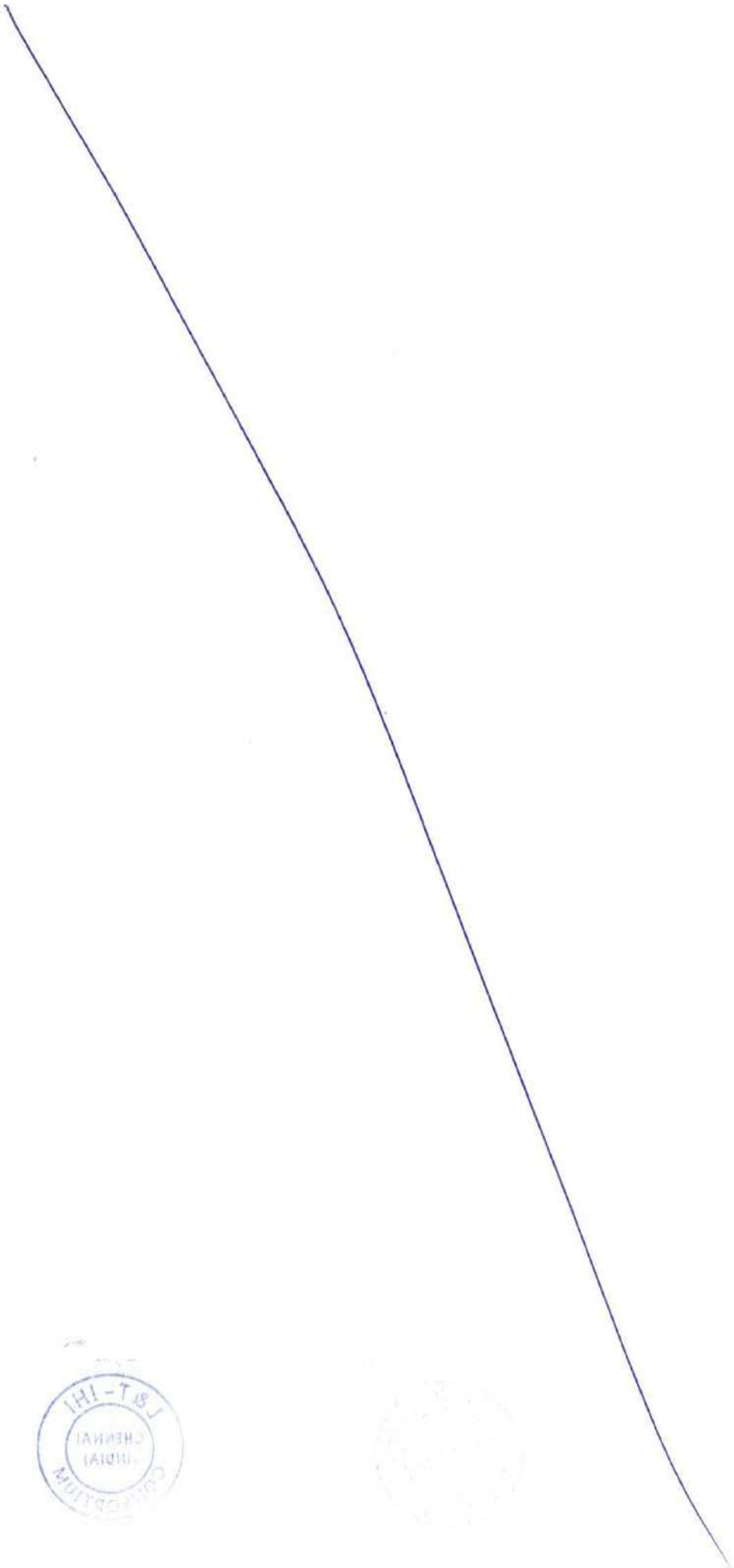


(a) *Noise Barrier/View Barrier* (b) *Safety fence*

Figure 11-3 Typical dimensions of noise barriers, view barriers and safety fences (ref. MMRDA tender drawing B-054 rev.01).

11.6 SECONDARY RESCUE STATIONS

Secondary rescue stations shall be provided on the south side of the MTHL at approx. Ch. 7+000 km and on the north side at approx. Ch. 14+000 km.



The secondary rescue stations shall each comprise one span length (minimum 50 m) and shall be 7.0 m wide. Loading and deck surfacing shall be as for the main bridge structures.

11.7 SUBSTATION PLATFORMS

Substation platforms shall be provided next to the MTHL on each side, at approx. 3 km spacing. Each platform shall have its own separate piled foundation, shall be 5 m x 5 m on plan and shall be able to support an imposed load of 5.0 tonnes. The finished soffit level of each platform shall be above the soffit level of the adjacent bridge deck box girder.

11.8 ACCESS FACILITIES

Gantries

An inspection gantry shall be provided under each steel box girder bridge. (Note. Each steel box girder bridge may comprise more than one expansion section.)

Live loading on inspection gantries shall be in accordance with §0, above.

Box girders

Box girders shall be provided with an interior access walkway 1.0 m wide. Live loading on access walkways shall be in accordance with §0, above.

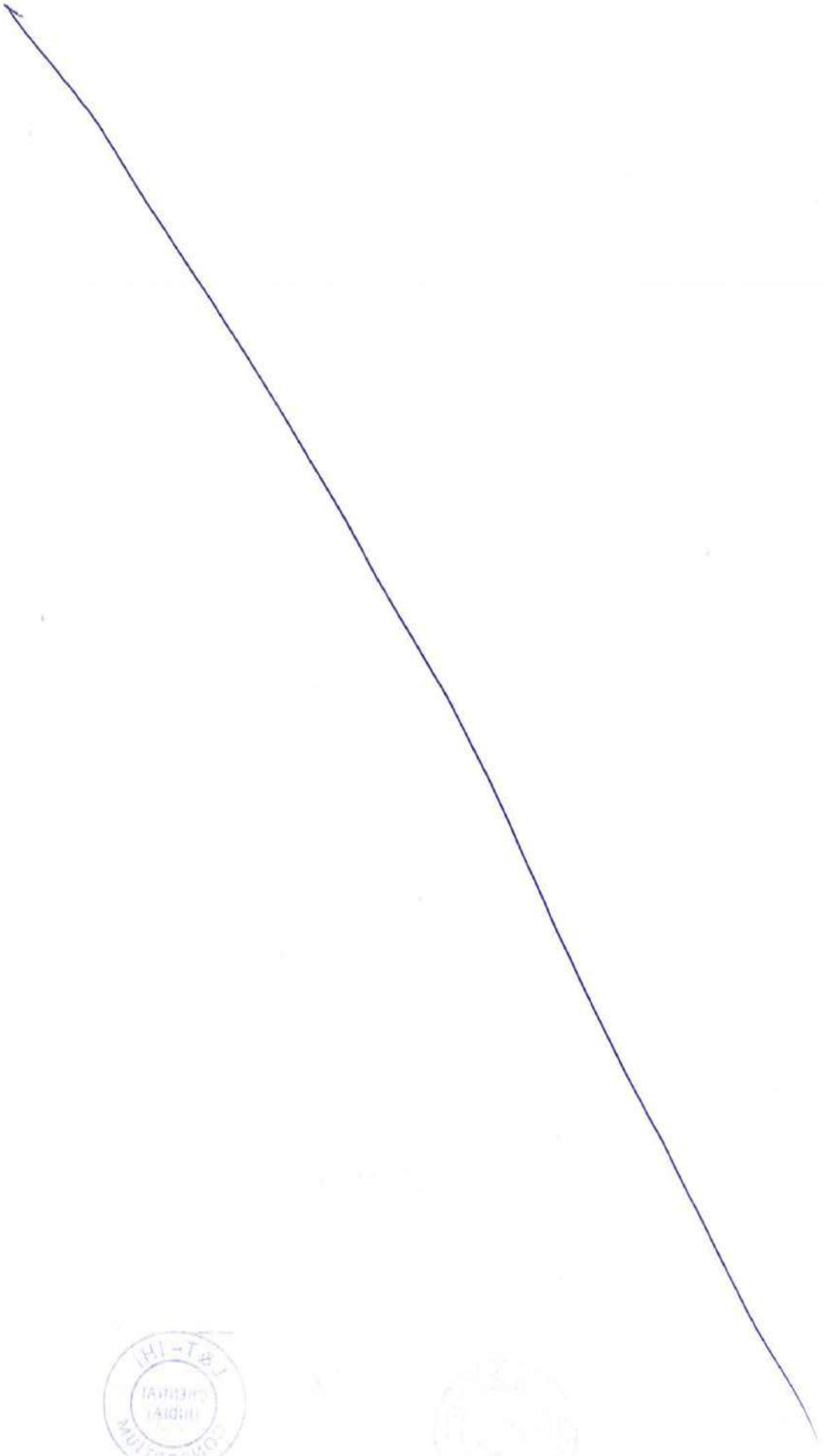
Access to the inside of the box girders of the main carriageways and shall be provided at maximum 1.0 km intervals.

Piers

Pier tops with bearings shall be provided with Access footways 1.0 m wide. Ladders shall be provided from the pile cap to the walkway. Live loading on access walkways shall be in accordance with §0, above.

11.9 DRAINAGE

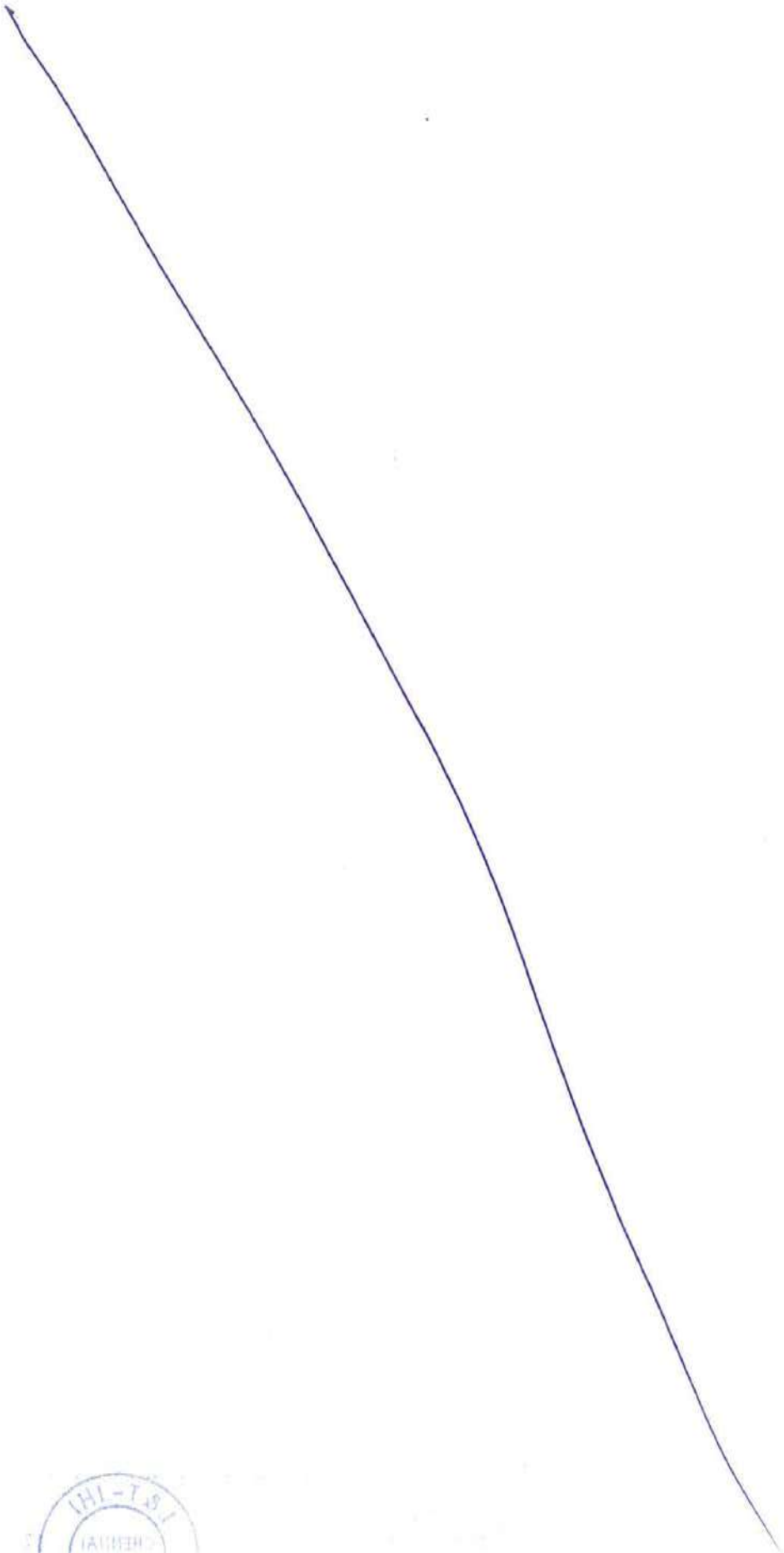
Bridge deck drainage design shall confirm with IRC:SP-42-1994.



Appendix Design Standards

IRC standards and guidelines

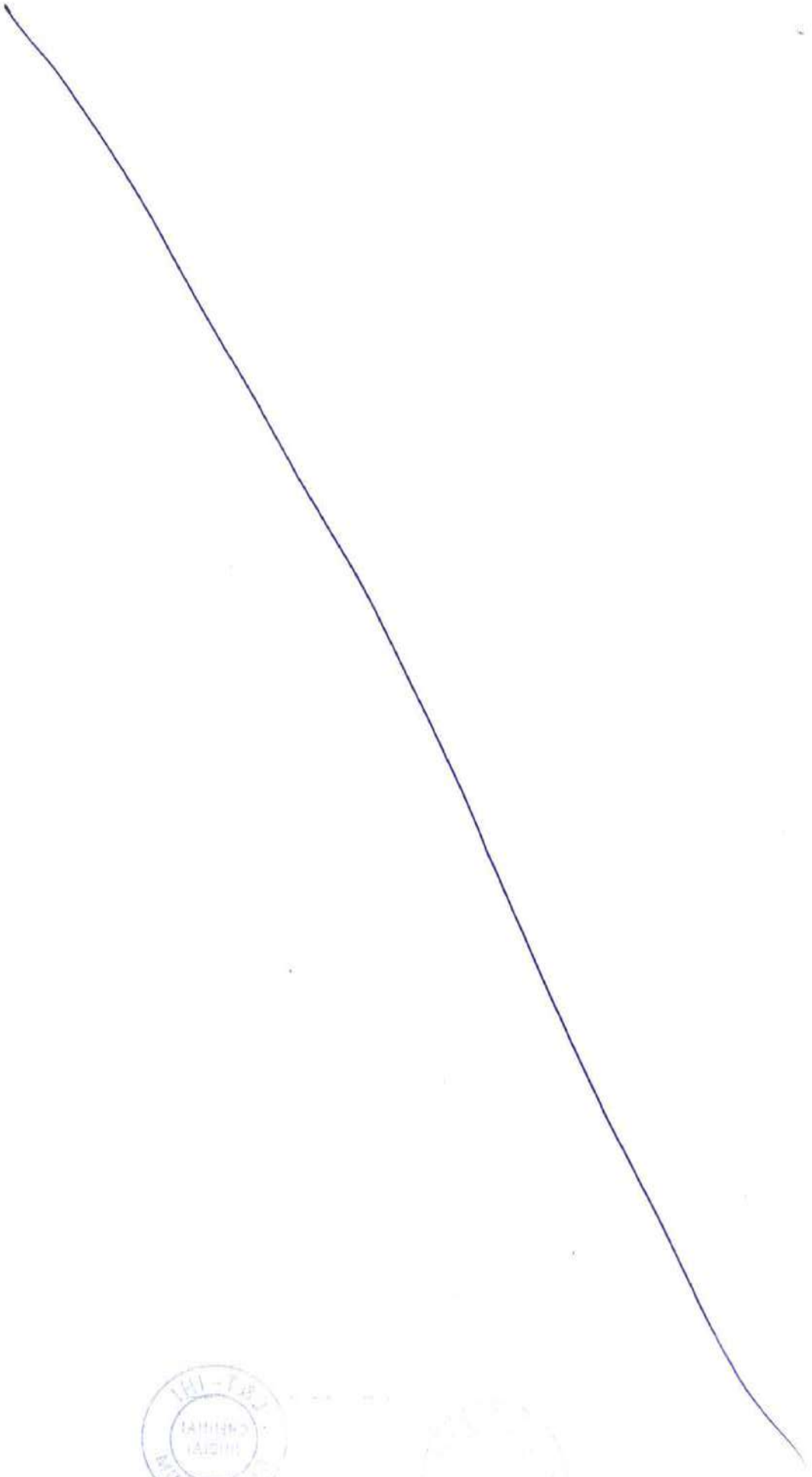
IRC:5-1998	Standard Specifications and Code of Practice for Road Bridges, Section: I, General Features of Design
IRC:6-2014	Standard Specifications and Code of Practice for Road Bridges, Section: II, Loads and Stresses
IRC:6-2017	Standard Specifications and Code of Practice for Road Bridges, Section: II, Loads and Load Combinations
IRC:18-2000	Design Criteria for Prestressed Concrete Road Bridges (Post-Tensioned Concrete)
IRC:21-2000	Standard Specifications and Code of Practice for Road Bridges, Section: III, Cement Concrete
IRC:78-2014	Standard Specifications and Code of Practice for Road Bridges, Section: VII, Foundations and Substructure
IRC:83 (Part II)-2015	Standard Specifications and Code of Practice for Road Bridges, Section IX, Bearings, Part II: Elastomeric Bearings.
IRC:83 (Part III)-2002	Standard Specifications and Code of Practice for Road Bridges, Section IX, Bearings, Part III: POT, POT-CUM-PTFE, PIN and Metallic Guide Bearings.
IRC:83 (Part IV)-2014	Standard Specifications and Code of Practice for Road Bridges, Section IX, Bearings, Part IV: Spherical and Cylindrical Bearings.
IRC: 84-1983	Code of Practice for Curing of Cement Concrete Pavements
IRC:112-2011	Code of Practice for Concrete Road Bridges
IRC:SP-42-1994	Guidelines on Road Drainage



IRC:SP-65-2005	Guidelines for Design and Construction of Segmental Bridges
IRC:SP-67-2005	Guidelines of use of External Unbonded Prestressing Tendons in Bridge Structures
IRC:SP-69-2011	Guidelines and Specifications for Expansion Joints.

IS standards

IS 1786 : 2008	High Strength Deformed Steel Bars and Wires for Concrete Reinforcement - Specification
IS 1893 (Part 1) : 2002	Criteria for Earthquake Resistant Design of Structures. Part 1: General Provisions and Buildings.
IS 1893 (Part 2) : 2002	Criteria for Earthquake Resistant Design of Structures. Part 3: Bridges and Retaining Walls
IS 2090 : 1983	Specification for High Tensile Steel Bars used in Prestressed Concrete (Reaffirmed 2000)
IS 2629: 1985	Recommended practice for hot-dip galvanising of iron and steel (Reaffirmed 1994) + Amendment No.1 (December 1988)
IS 2911 (Part 1/ Section 2) : 2010	Design and construction of pile foundations – Code of practice. Part 1: Concrete Piles. Section 2: Bored cast in-situ concrete piles
IS 2911 (Part 4) : 2013	Code of practice for design and construction of pile foundations. Part 4: Load test on piles
IS 4651 (Part III) 1997	Code of Practice for Planning and Design of Ports and Harbours, Part III: Loading.
IS 4759 : 1996	Hot-dip zinc coatings on structural steel and other allied products – Specification (Third revision) (Incorporating Amendment No. 1) (Edition 4.1) (Reaffirmed 2006)
IS 6403 : 1983	Code of practice for determination of bearing capacity of shallow foundations (Reaffirmed 2002)



IS 12070 : 1987	Code of practice for design and construction of shallow foundations on rocks (Reaffirmed 2010)
IS 13620 : 1993	Fusion bonded epoxy coated reinforcing bars - Specification
IS 14268 : 1995	Uncoated stress relieved low relaxation seven-ply strand for prestressed concrete – Specification (Reaffirmed 2003)
IS 14593 : 1998	Design and construction of bored cast-in-situ piles founded rocks – Guidelines (Reaffirmed 2003)

MoRT&H specifications

MoRT&H	Ministry of Road Transport and Highways 'Specifications for Road and Bridge Works'

Japan Road Association & other Japanese documents

Specifications for Highway Bridges - Part I – Common (March 2002)

Specifications for Highway Bridges - Part II - Steel Bridges (March 2002)

Guidelines for Fatigue Design of Steel Highway Bridges (2002)

Painting Manual for Steel Highway Bridges (1990)

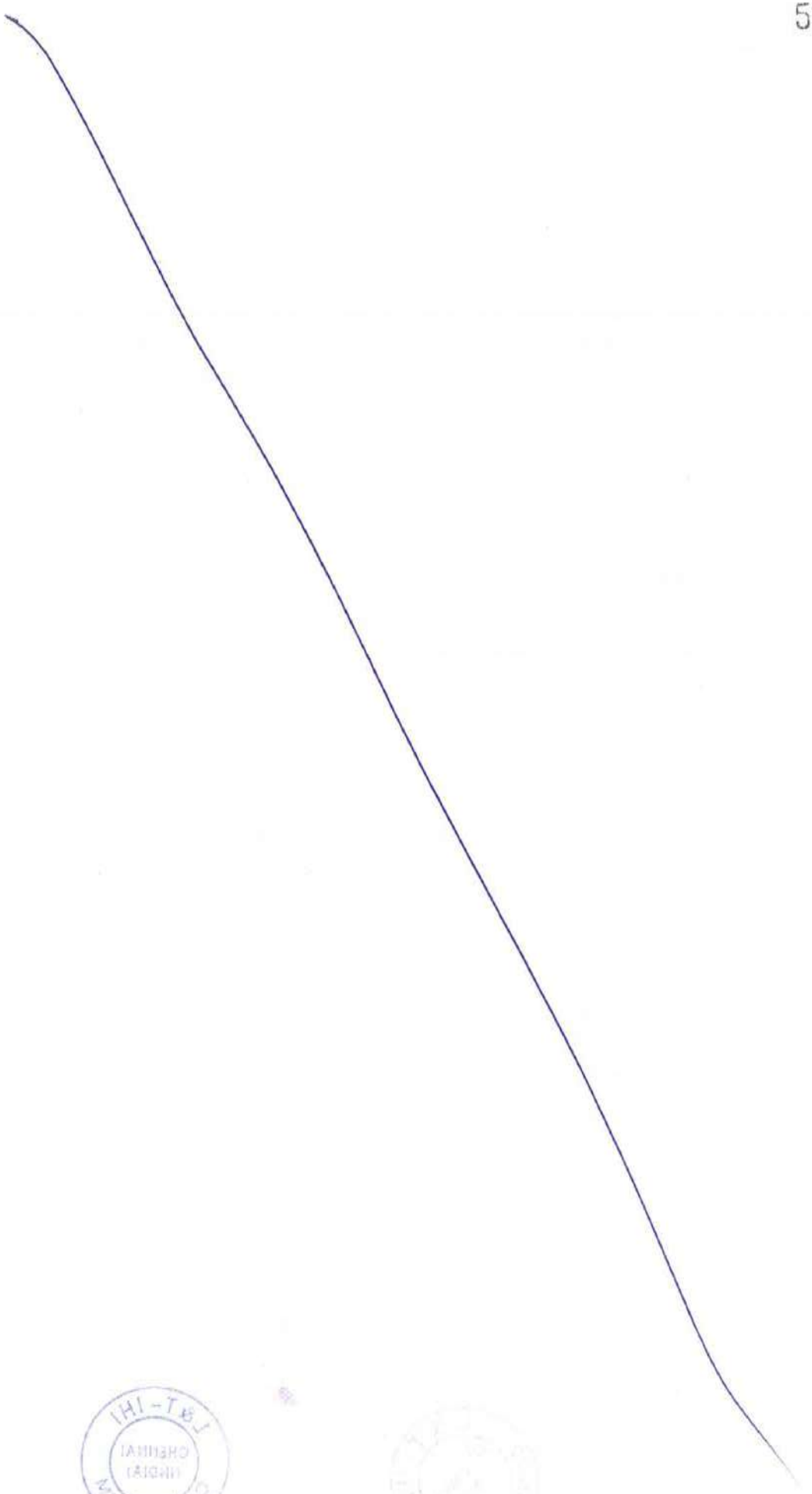
Guidelines for Corrosion Protection of Steel Highway Bridges (2014)

JIS 2000	A1416:	Acoustics - Method For Laboratory Measurement Of Airborne Sound Insulation Of Building Elements (Japanese Standards Association)

Design Manual for Expressways. Quality and tests of noise barrier panel. Nexco-East.

European standards

EN 2005	1991-1-4:	Euroccode 1: Actions on structures – Part 1-4: General actions – Wind actions



EN 1991-1-5: 2003	Euroccode 1: Actions on structures – Part 1-5: General actions – Thermal actions
prEN 10138-4	Prestressing Steels – Part 4: Bars

UK Highways Agency documents

BD 58/94	The design of concrete highway bridges and structures with external and unbonded prestressing (Standard)
BA 58/94	The design of concrete highway bridges and structures with external and unbonded prestressing (Advice Note to BD 58/94)

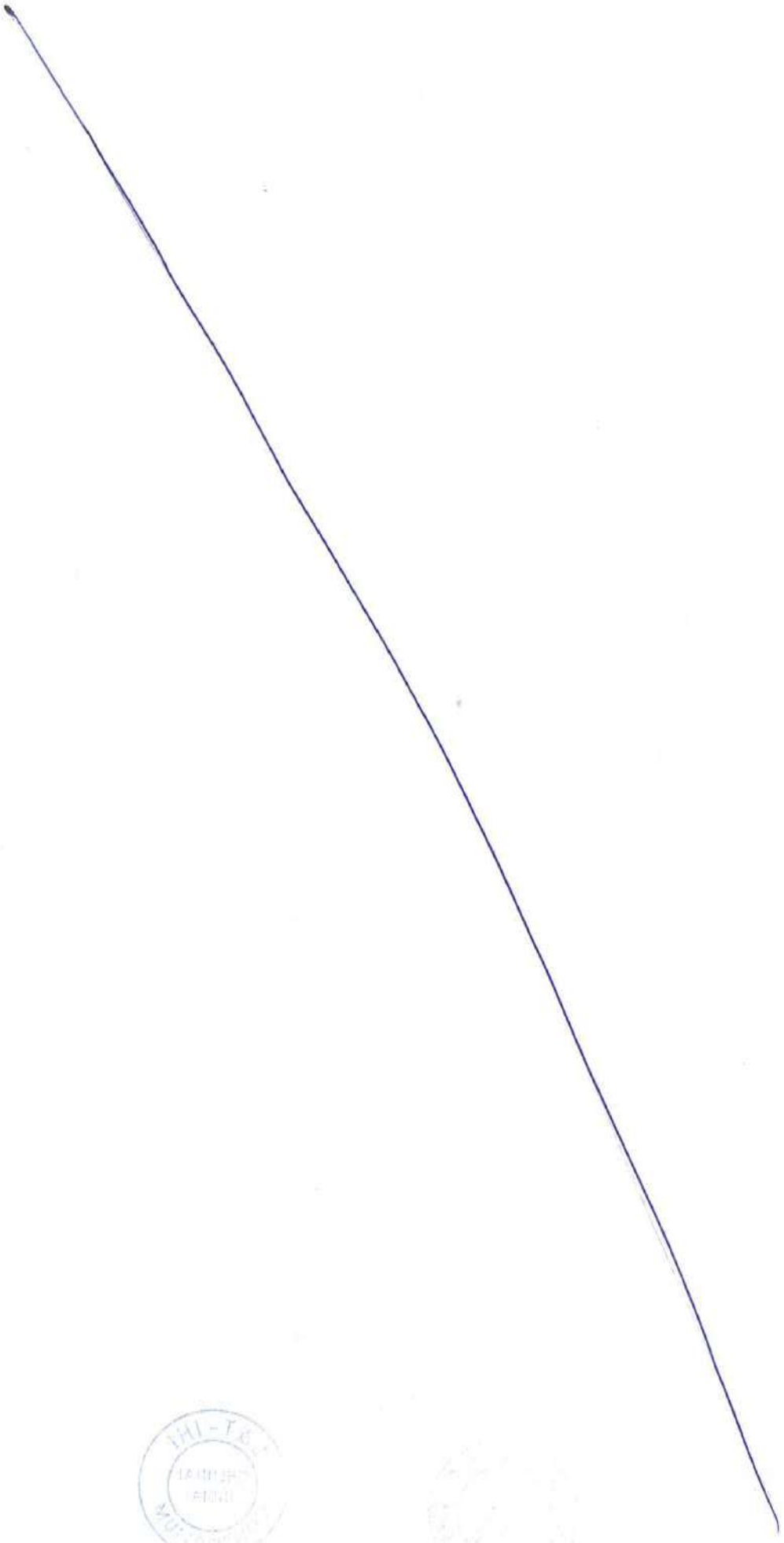
US documents

U.S. Army Coastal Research Centre Technical Report No.4. 'Shore Protection, Planning & Design'

Department of the Army (USA) Coastal Engineering Research Centre 'Shore Protection Manual'.

AASHTO LRFD Guide Specifications for Design and Construction of Segmental Concrete Bridges.

FHWA Hydraulic Engineering Circular HEC-21, Design of Bridge Drainage (1993)(FHWA doc. no. SA-92-010. NTIS doc. no. PB94-109584).



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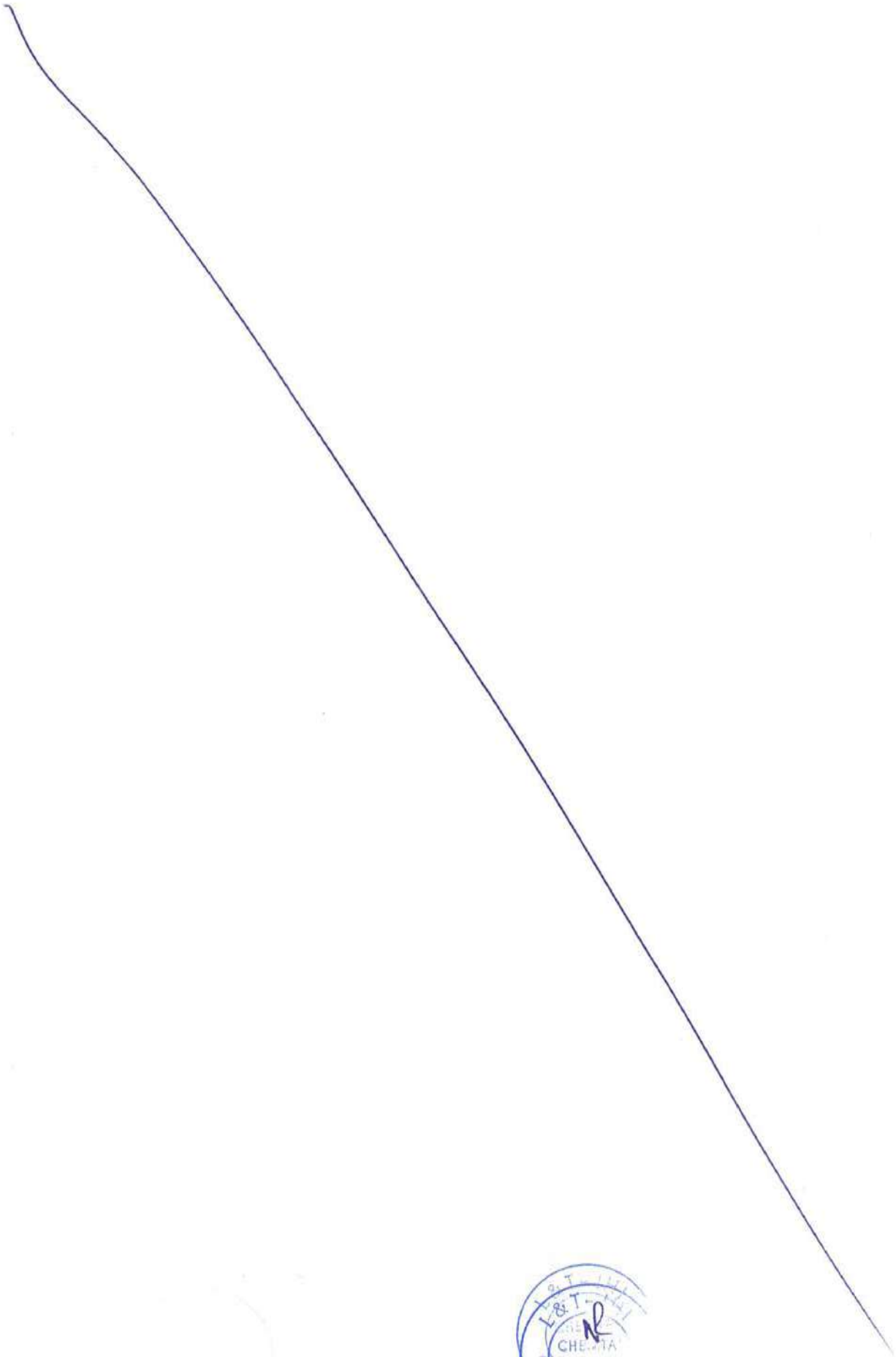
Vessel Impact Report

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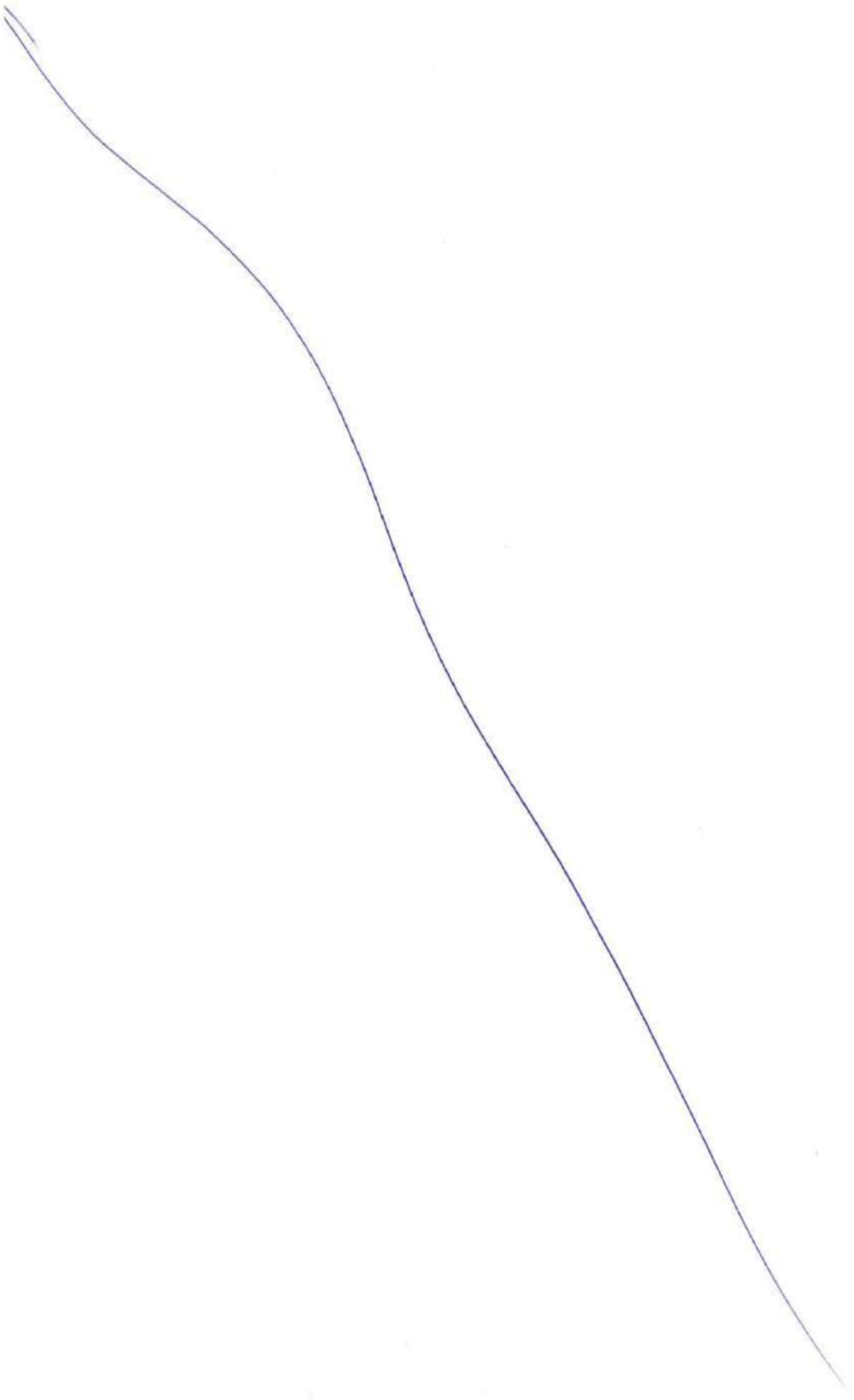


Vessel Impact Report

1 Introduction

This document outlines the design methodology and design forces for vessel impacts used in the bid design of package 1 and package 2 of the Mumbai Trans Harbour Link Project (MTHL).

2 Piers adjacent to the navigation channels

2.1 Requirements

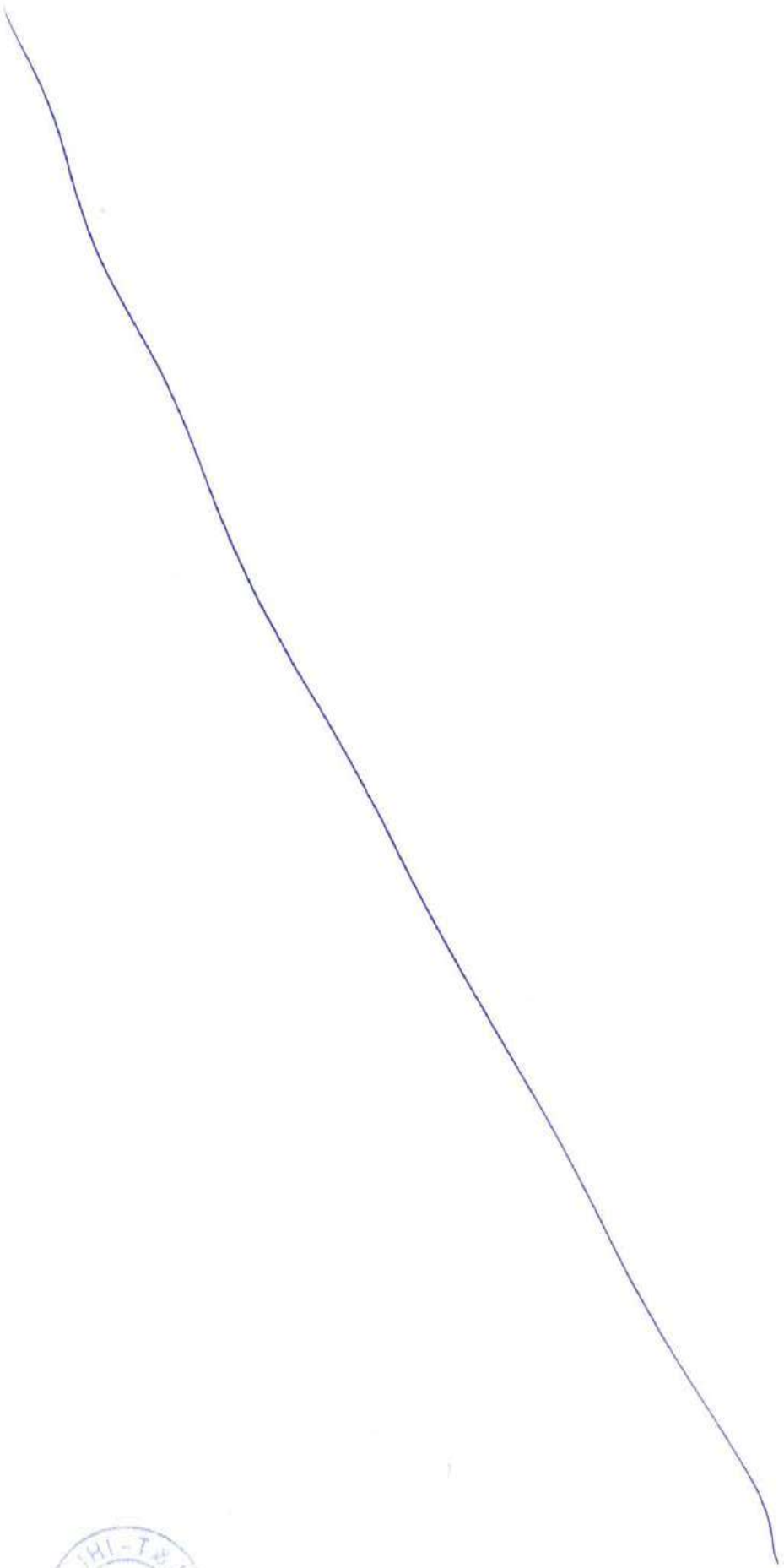
According to Addendum No. 5 the following requirements shall apply for barge impact on piers and foundations adjacent to the navigation spans. Quote.

"Type	*: Barge*
Class of Waterwa	*: VI & VII*
DWT	*: 6,000 tonnes*
Speed	*: As per IRC*

The analysis and design methodology for vessel collision shall follow AASHTO Guide Specification and Commentary for Vessel Collision Design of Highway Bridges, 2009 or the latest.

Bridge Operational Classification: "Critical/Essential"

Piers and foundations adjacent to the navigational channels shall be designed for the vessel collision forces OR the contractor may provide an appropriately designed protection system in which case shall design the foundations/piers with appropriately reduced impact forces consistent with the noted design codes and design guides." The design for the protection system shall be the more stringent of IRC-6 or AASHTO Guide for Vessel Collision Design of Highway Bridges, 2009 or the latest."



2.2 Methodology

The design methodology adopted for the piers adjacent to the navigation channels is as follows.

The foundations typically comprising groups of 10 nos. 2.2m dia. piles shall be able to resist the vessel collision force directly. However, individual piles exposed to damage caused by an impact will be protected. This protection system will ensure that the impact force is transferred to the pile cap allowing the entire pile group to take part in resisting the impact. For further understanding of this concept see Figure 2-1 below.

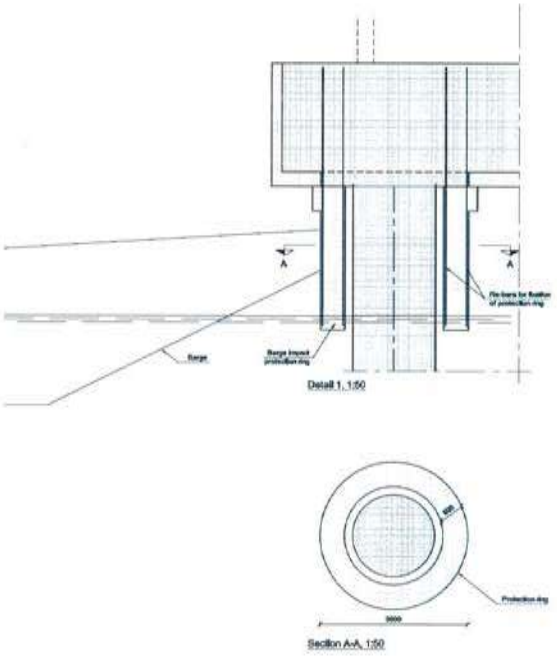
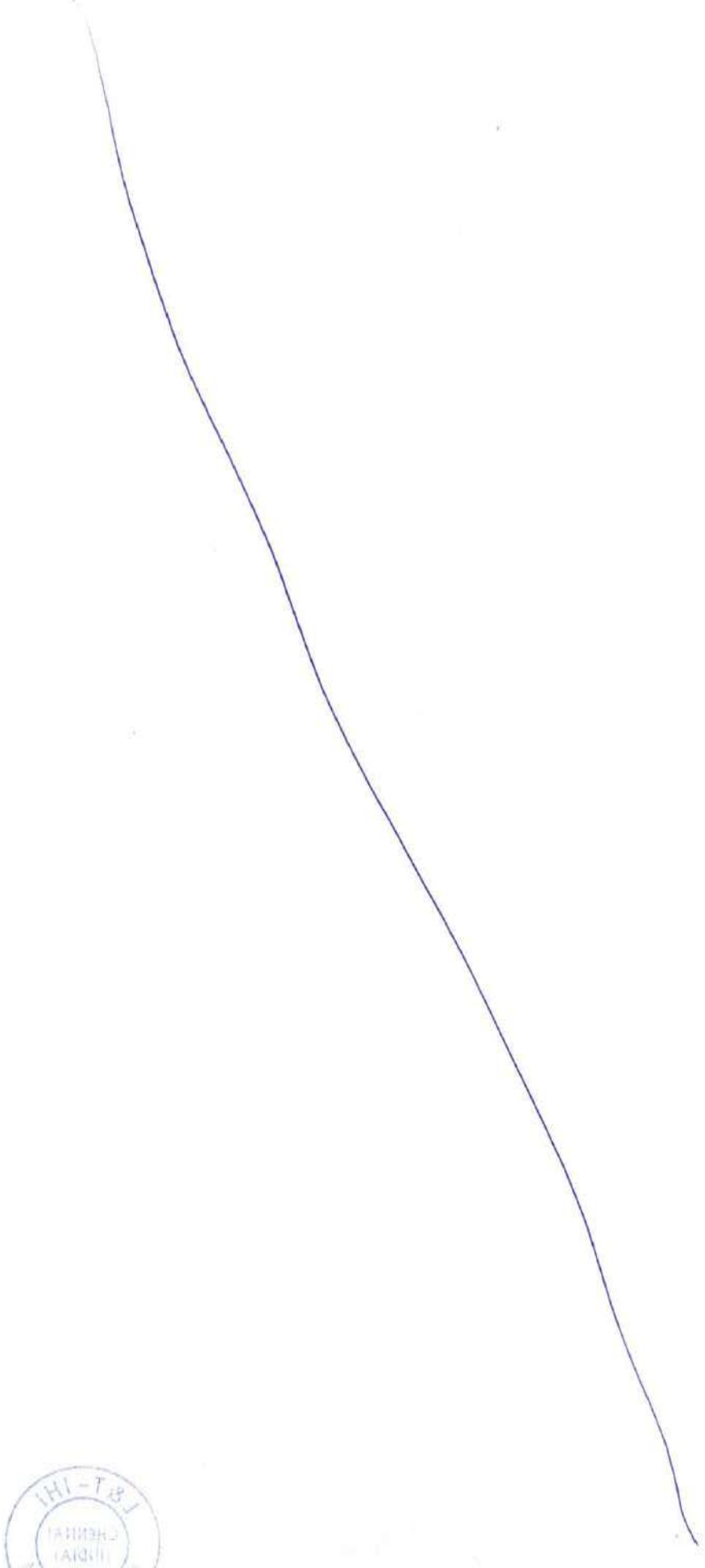


Figure 2-1 Protection rings for pile foundations adjacent to navigation channels



2.3 Impact force

Since tonnage has been specified to 6,000 DWT which is above the tonnage in IRC:6-2014 for class of waterway VI & VII of 4,000 DWT the following interpretation is made for barge tows as marked up in with reference to Annex E in IRC:&-2014.

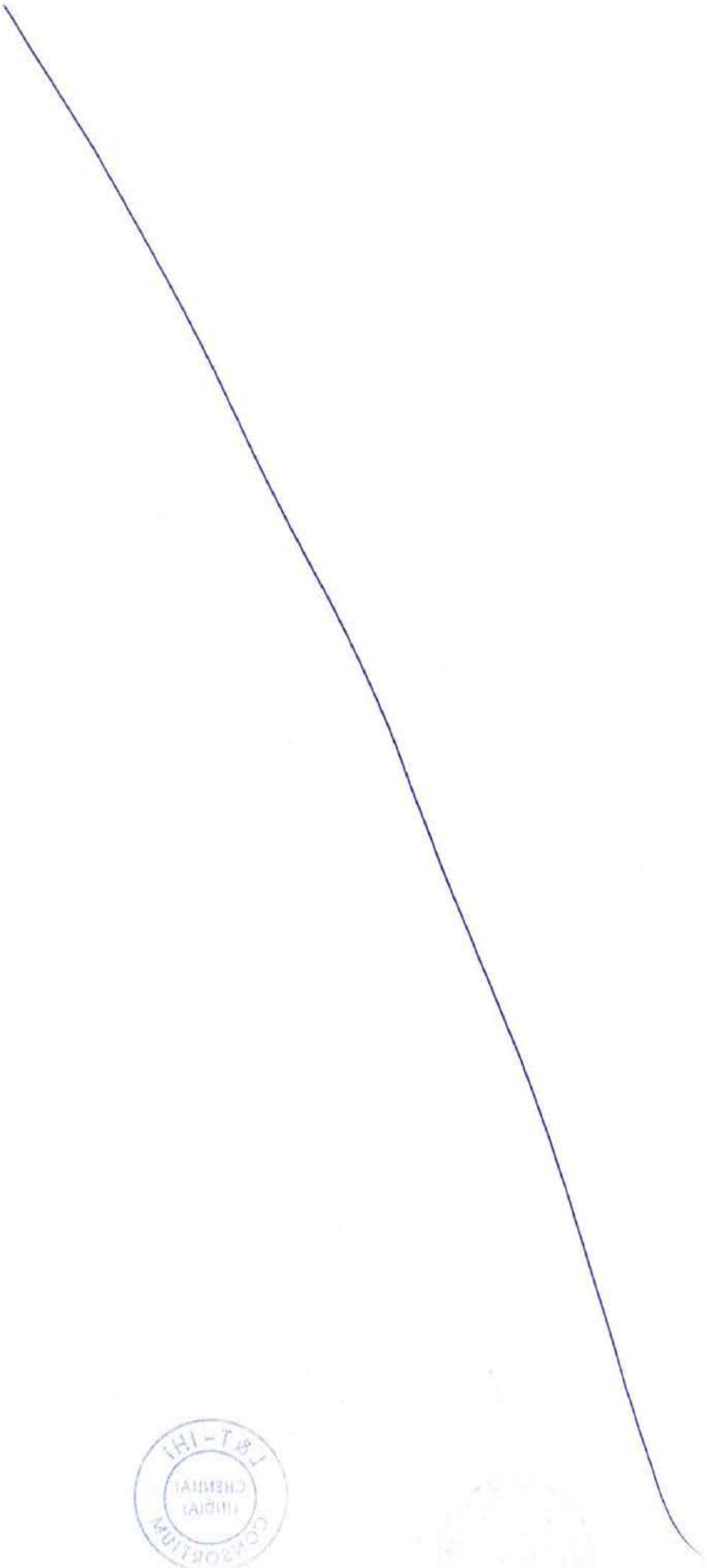
Annex E
(Clause 220.1)
CLASSIFICATION OF INLAND WATERWAYS IN INDIA

Class of Waterway	Tonnage (DWT) of SPV (T)	Barge Units			Minimum Dimensions of Navigational Channels in Lean Seasons					Minimum Clearances for cross structure		
					Rivers		Canals			Horizontal Clearance		
		Dimension of Single Barge (LxBxD) (m)	Dimensionof Barge Units (LxBxD) (m)	Tonnage of Barge Units (DWT) (T)	Depth* (m)	Bottom Width (m)	Depth* (m)	Bottom Width (m)	Radius at Bend (m)	Rivers (m)	Canals (m)	Vertical Clearance** (m)
I	100	32x5x1.0	80x5x1.0	200	1.20	30	1.50	20	300	30	20	4.0
II	300	45x8x1.2	110x8x1.2	600	1.40	40	1.80	30	500	40	30	5.0
III	500	58x8x1.5	141x9x1.5	1000	1.70	50	2.20	40	700	50	40	7.0
IV	1000	70x12x1.6	170x12x1.8	2000	2.00	50	2.50	50	800	50	50	10.0
V	1000	70x12x1.6	170x24x1.8	4000	2.00	80	-	-	800	80	-	10.0
VI	2000	86x14x2.5	210x14x2.5	4000	2.75	80	3.50	60	500	60	60	10.0
VII	2000	86x14x2.5	210x26x2.5	8000	2.75	100	-	-	900	100	-	10.0

Figure 2-2 Interpretation of 6,000 DWT requirement for class VI and VII waterway

According to AASHTO Guide Specification and Commentary for Vessel Collision Design of Highway Bridges, 2009 C3.12.2 only the number of barges in the length of the tow counts (the barges in the width of the tow are assumed to break away quickly upon impact and are not included in the kinetic energy and force computation).

Therefore, the SPV + 3 barge units are considered for the barge tow.



Vessel Impact Report

Vessel collision energy (KE):

$KE = c_H \times \frac{1}{2} \times m \times v^2$

m = total displacement tonnage = weight of empty barge + cargo and ballast.
v = vessel impact speed.
c_H = hydrodynamic mass coefficient

$m_{total} = m_{SPV} + 3 \times m_{barge\ unit}$

According to AASHTO Guide Specification and Commentary for Vessel Collision Design of Highway Bridges, 2009 Fig. 3.5.1-1 a Jumbo Hopper barge has a cargo capacity (DWT) of 1,700 t and a loaded displacement (m) of 1,900 t. Accordingly, a 2,000 DWT barge is considered to have a total displacement tonnage

$m_{2000\ DWT\ barge} = 2,000 \times 1,900 / 1,700 = 2,235$ t.

m_{SPV} is taken as 2,000 t according to IRC:6-2014 Annex E.

Based on the above the total displacement tonnage and kinetic energy is as follows:

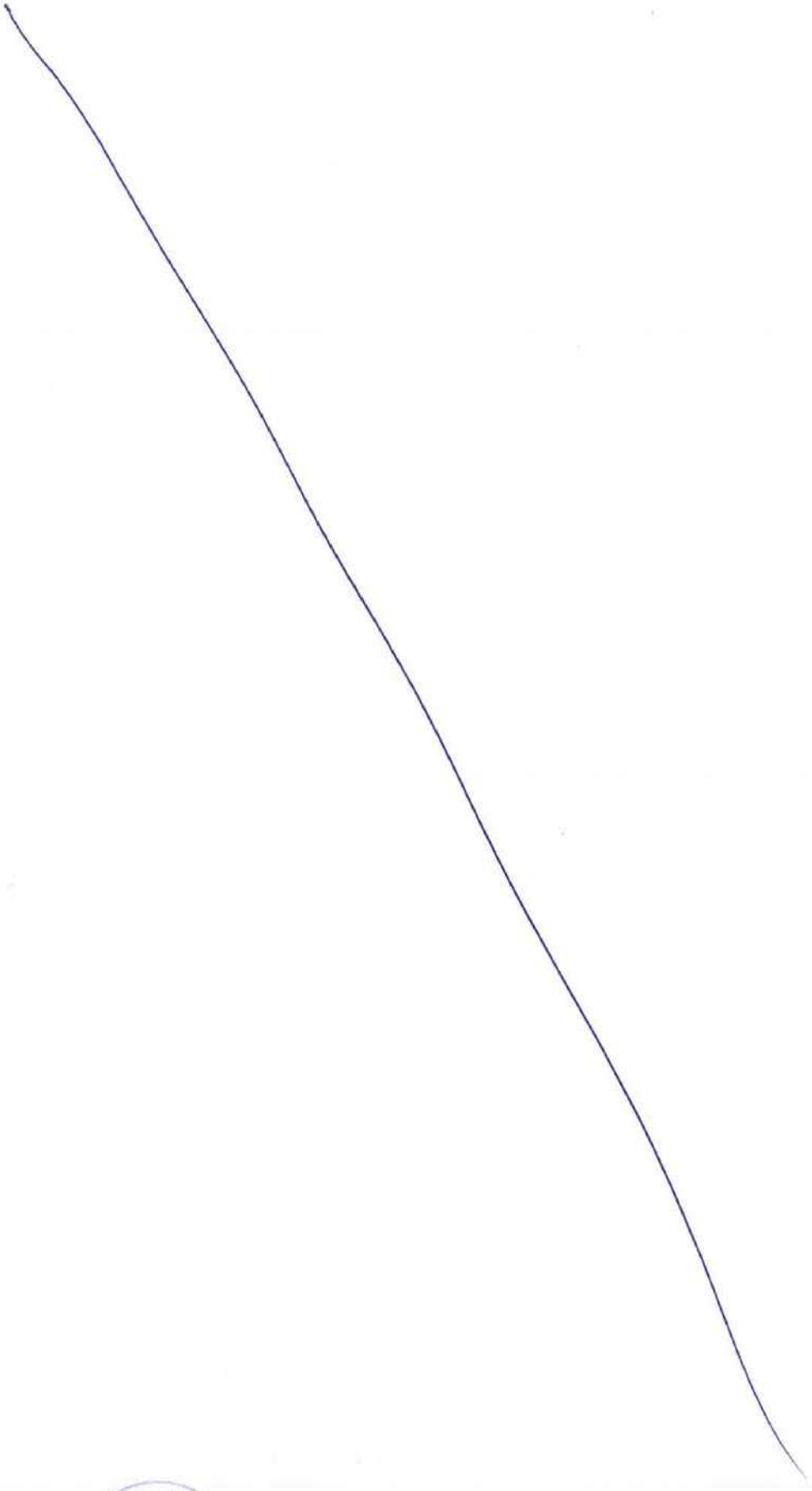
$m_{total} = 2,000 + 3 \times 2,235 = 8,705$ t.

$KE = E_B = \frac{1}{2} \times c_H \times m_{total} \times v^2$

$c_H = 1.05$ considering that underkeel clearance > 0.5 x draft.

v = 2.1 m/s for laden barges as per IRC:6-2014.

$E_B = \frac{1}{2} \times 8,705 \times 10^3 \times 2.1^2 \times 10^{-6}$ MNm = 19.2 MNm



Barge bow damage depth:

a_B ($(1 + 0.13E_B)^{½} - 1$) x 3.1 = 2.70 m

Barge collision force for a_B > 0.1m

$P_B = 6 + 1.6 \times a_B = 6 + 1.6 \times 2.7 =$ **10.3 MN.**

3 All other marine piers

3.1 Requirements

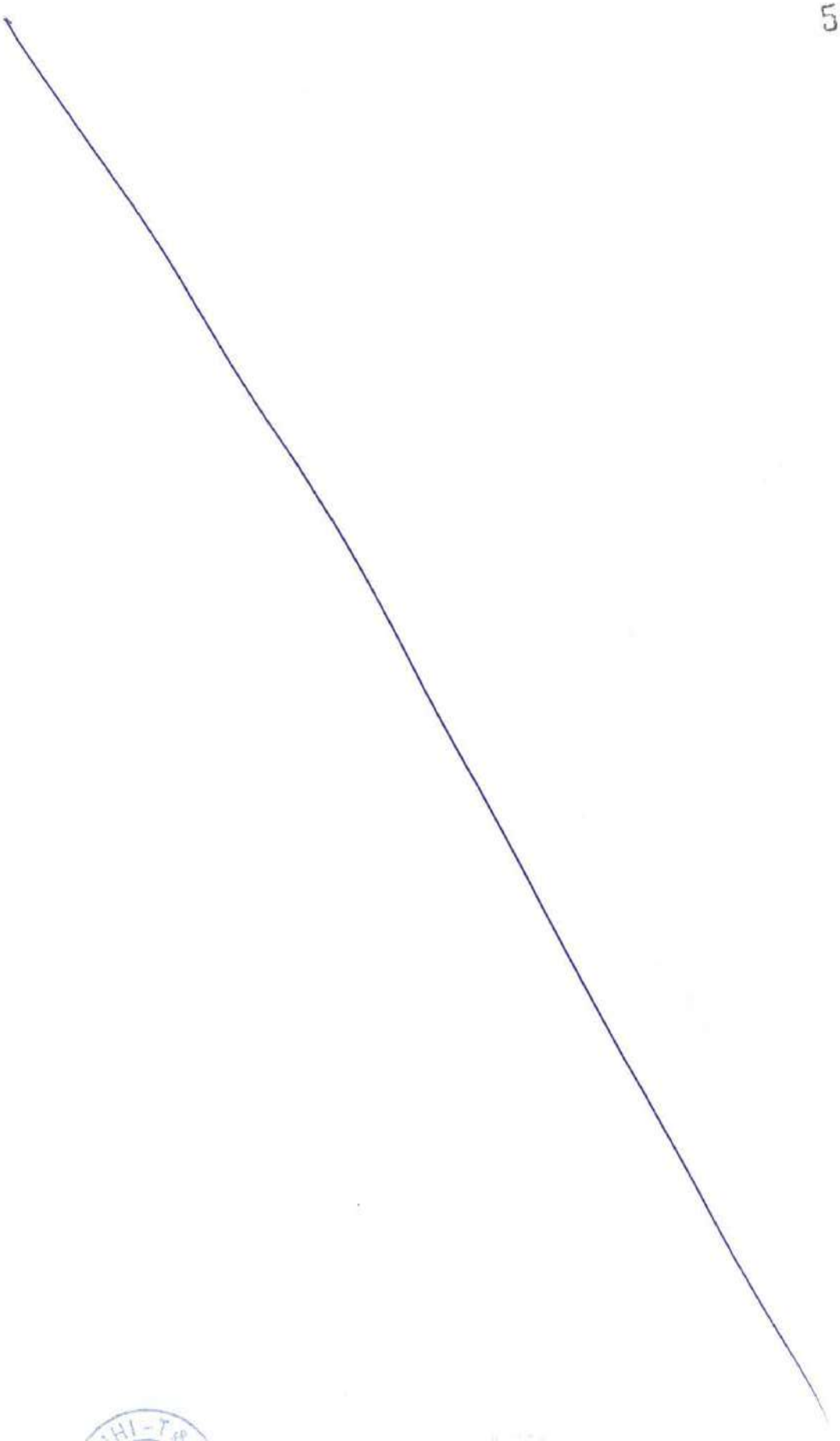
According to Addendum No. 5 the following requirements shall apply for barge impact on piers and foundations for all other marine piers. Quote.

"For all marine piers other than those adjacent to the navigational spans, the structure shall be designed for at least the minimum vessel impact forces more stringent out of IRC 6 or AASHTO guidelines (probabilistic method).

All those piles for marine piers which are exposed with sufficient freeboard to allow accidental impact from a barge and located in sufficiently deep waters for laden barges as per IRC-6, shall be designed and detailed for protection against all probable structural damages."

3.1.1 IRC 6

Following IRC:6-2017 220.1(8) in non-navigable portion of the waterways, the possibility of smaller barges using these portions and likely to cause accidental impact shall be examined from consideration of the available draft and type of barges that ply on the waterway. In such case possibility exists, the piers shall be designed to resist



a lower force of barge impact caused by the smaller barges as compared to the navigational span.

Following IRC:6-2017 220.1(9) for navigable waterways which has not been classified by IWAI, but where barges are plying, one of class from I & VI should be chosen as applicable, based on the local survey of crafts plying in the waterway. Where reliable data is not available minimum class I shall be assigned.

3.1.2 AASHTO Guidelines (probabilistic method)

This method is a probability-based analysis procedure for determining the design vessel. In order to use this method a significant amount of input data for the vessel, bridge and waterway characteristics are required. Such detailed input data are not available at the present stage.

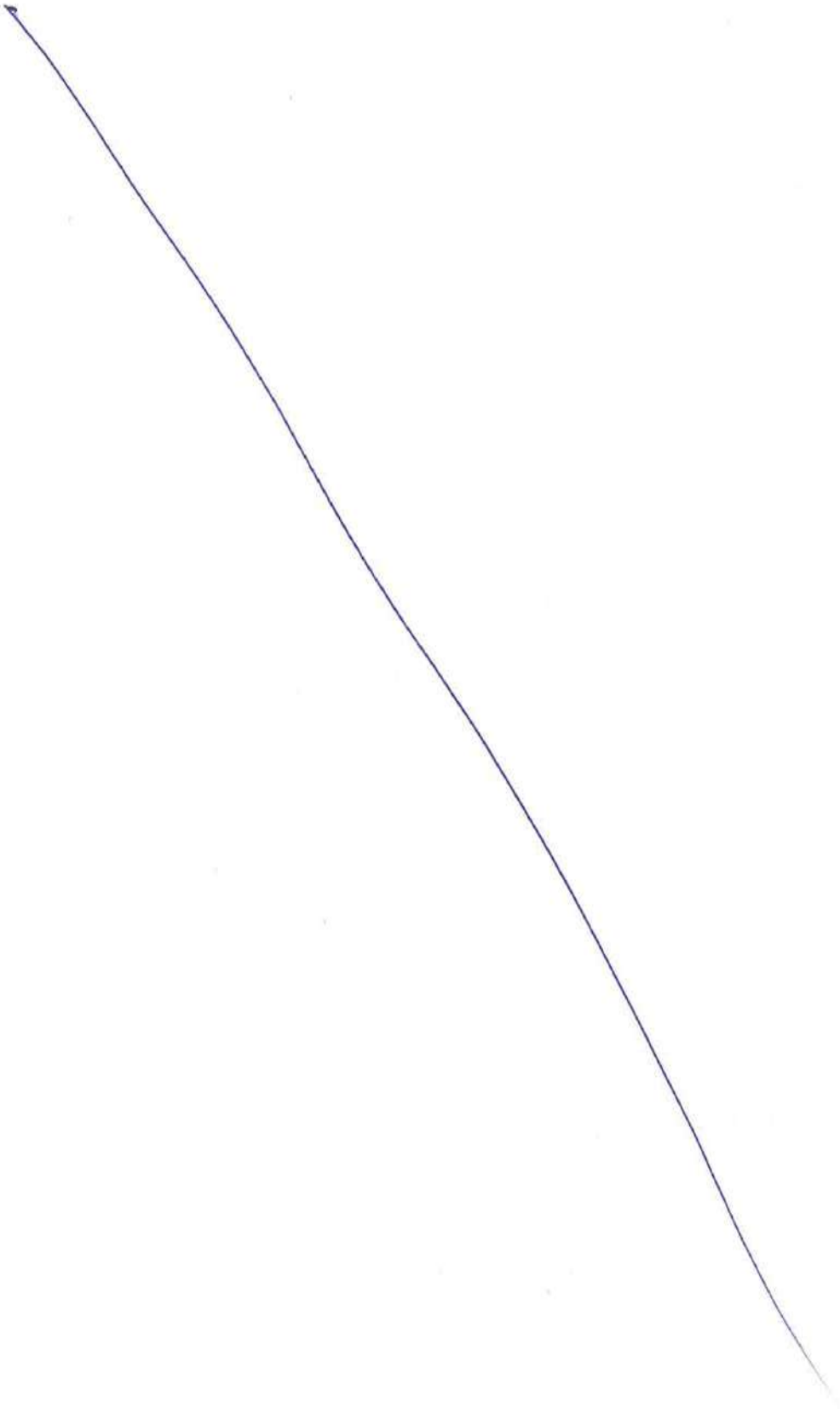
3.2 Methodology

The design methodology adopted for all other marine piers is that a single pile hit by a barge shall be able to resist the impact force as an accidental load.

3.3 Impact load

The Impact load will depend on the actual barges plying in the area as stated in IRC-6.

The minimum impact force is considered according to a barge tow for class I waterway since no reliable data are available.



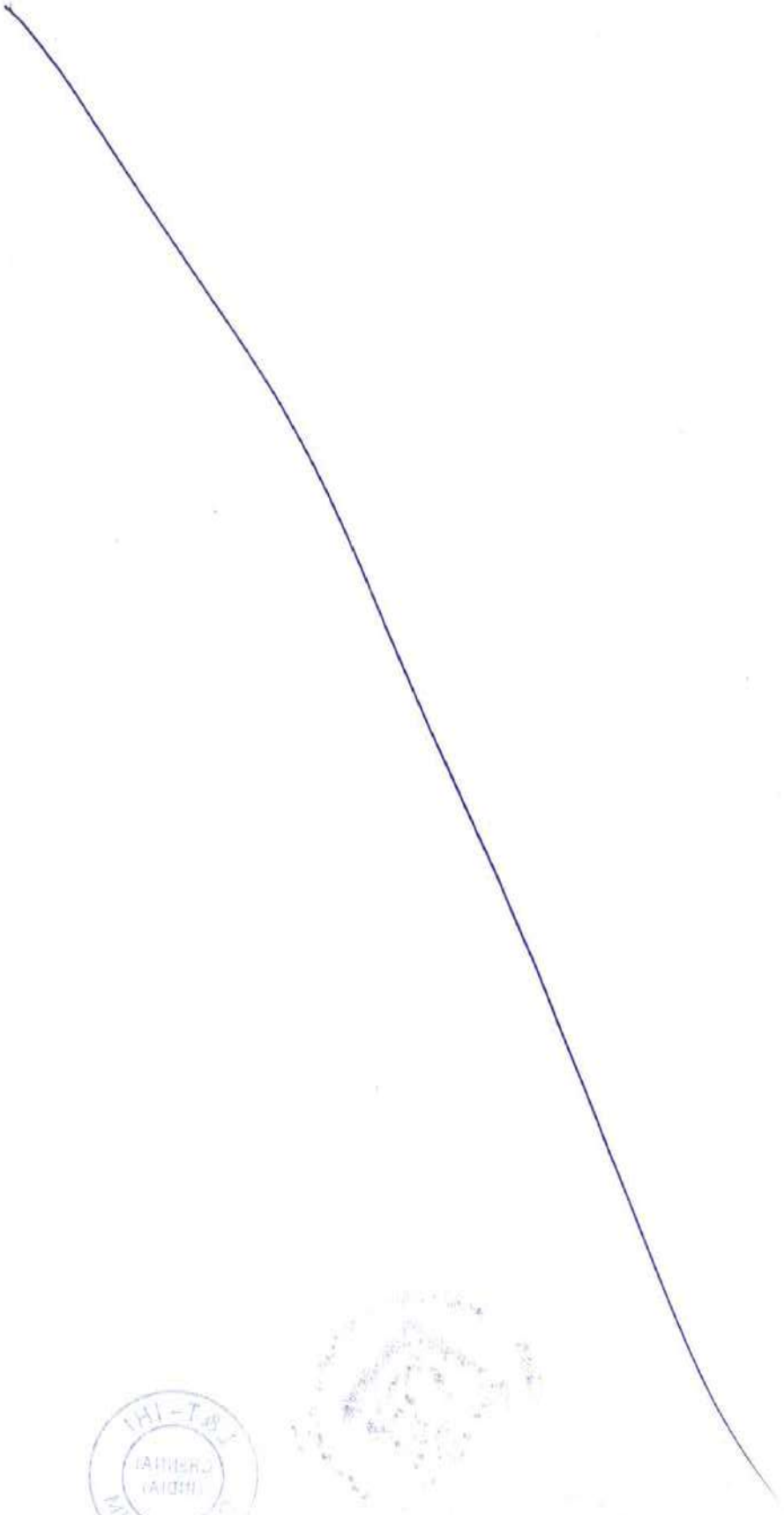
Vessel Impact Report

Class I waterway:

$KE = 500 c_H W v^2 = 500 \times 1.05 \times (100 + 2 \times 200) \times 2.1^2 \times 10^{-6} = 1.2$ MNm

$a_B = 3100 \times ((1 + 1.3 \times 10^{-1} \times KE)^{0.5} - 1) \times 10^{-3} = 0.233$ m

$P_B = 6.0 + 1600 \times 10^{-3} \times 0.233 =$ **6.4 MN**



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L&T - IHI

Mumbai Trans Harbour Link Project (Package-1)

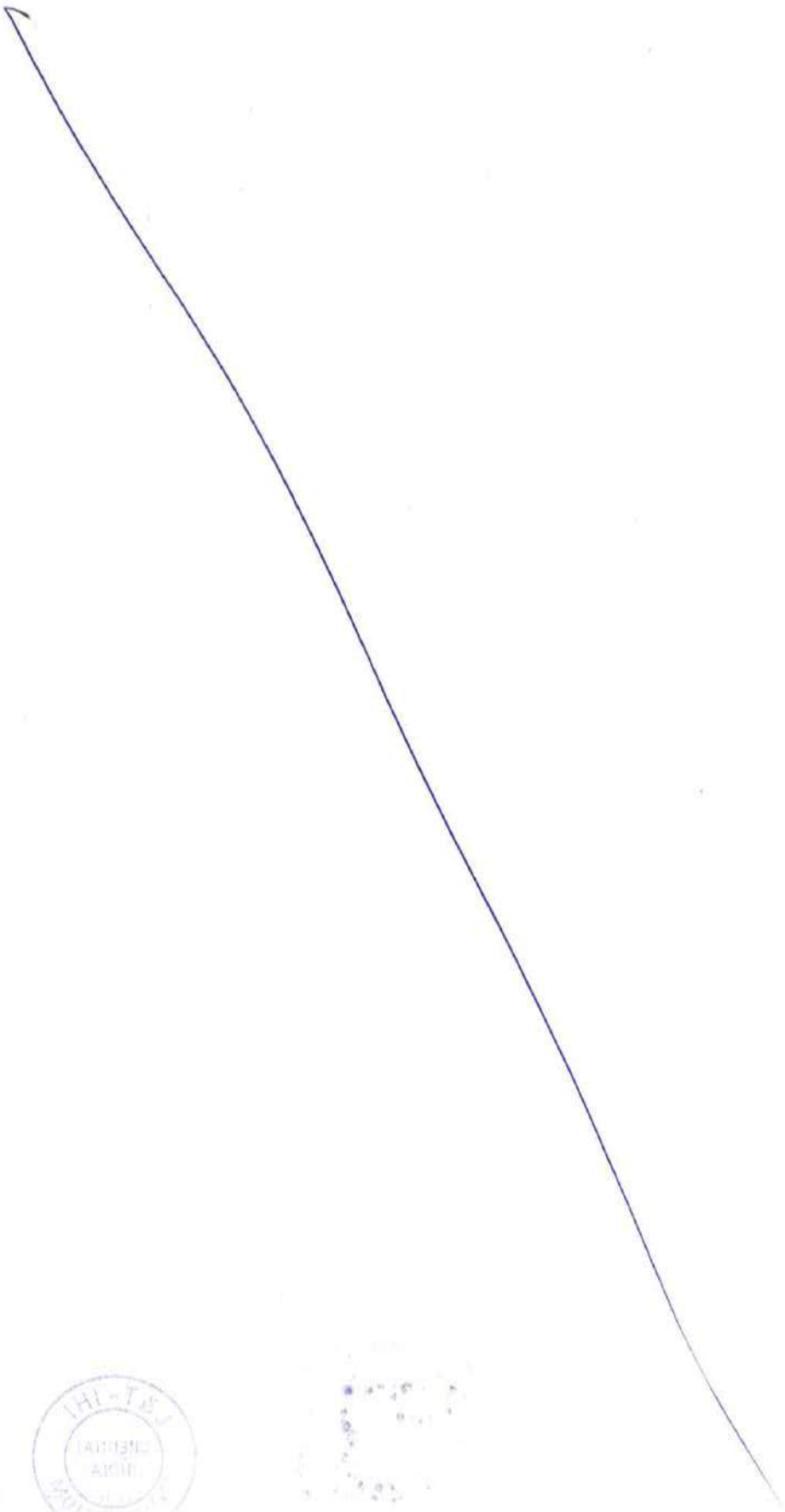
IFB No: MMRDA/ENG1/000752

Preliminary / Bidding Design

Design Drawings Enclosed Separately

MMRDA
MUMBAI METROPOLITAN REGION DEVELOPMENT AUTHORITY

L&T - IHI CONSORTIUM CHENNAI (INDIA)



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MMRDA
MUMBAI METROPOLITAN REGION DEVELOPMENT AUTHORITY

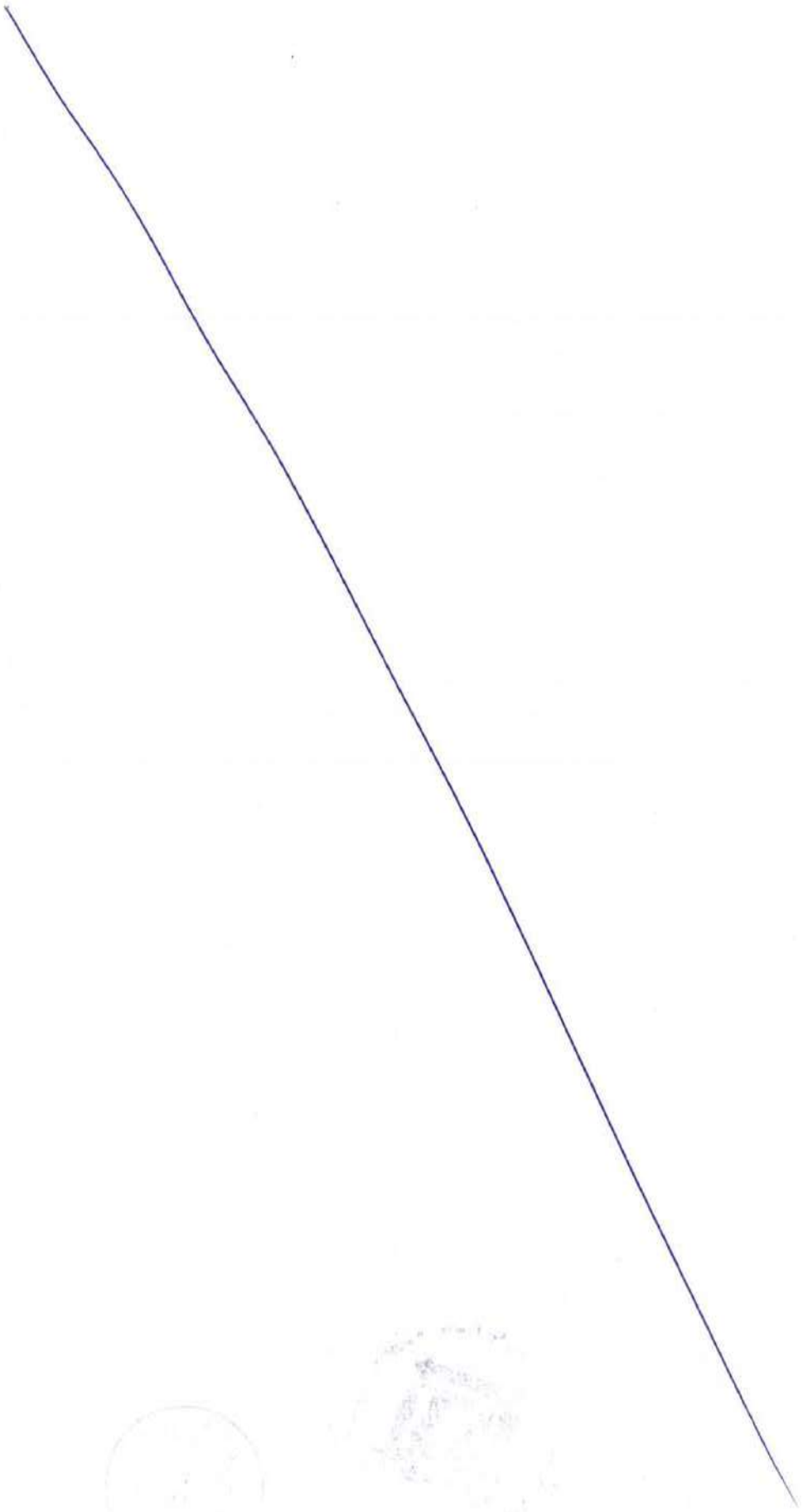
MUMBAI TRANS HARBOUR LINK PROJECT (PACKAGE-1)

IFB No: MMRDA/ENG1/000752

QUALITY ASSURANCE PLAN

L&T - IHI

L&T – IHI Consortium



PROJECT QUALITY PLAN

Mumbai Trans Harbor Link Project (Package 1)

L&T - IHI

L&T-IHI CONSORTIUM

5633
01328

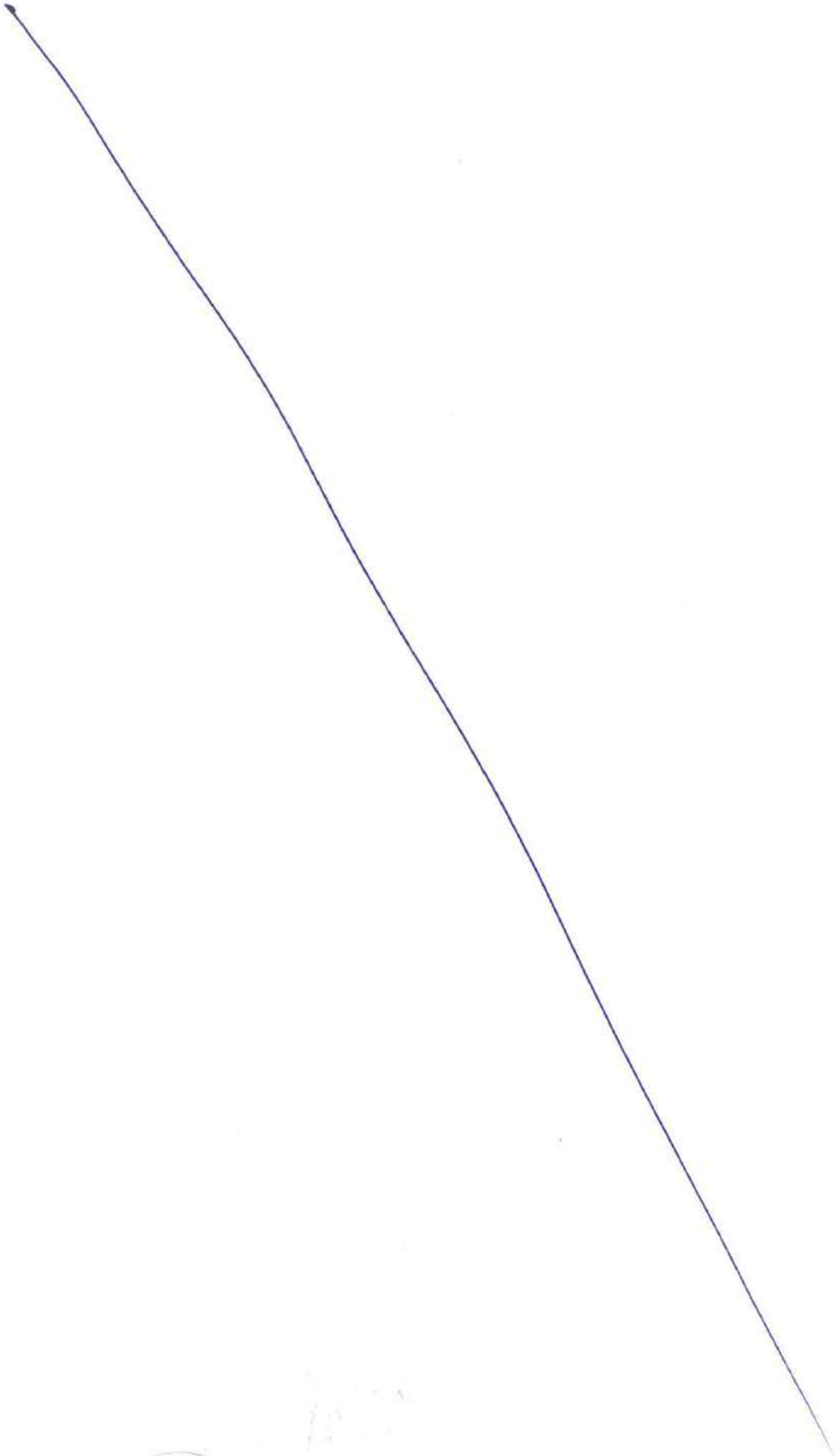
Quality Assurance Plan

REVISION RECORD SHEET

Rev. No.	Date	Description of Change
0		First Issue
1		a) Index modified (PQP/G3) b) Contents in PQP QMS clause No's: 4.1, 4.2, 4.3, 6.3, 7.1.2.6, 8.2.2 revised. c) Work procedures WP 01, WP 04 & WP 11revised. d) File list – Documents (Retention periods) introduced. e) File list – Records (Retention periods) introduced. f) Formats PQP/WP 01 F 01 (Quality Objectives), PQP/WP 09 F01 (MQR) and PQP/WP 16 F 03 (Audit report) revised. g) Formats PQP/WP 08 F01 (Statutory compliance report) and PQP/4.3 F01 (Scope of QMS) introduced.
		MODEL PROJECT QUALITY PLAN

TABLE G1: REVISION RECORD SHEET

FINAL PQP COPY	Prepared by QMS Coordinator (Site)	Reviewed ,Approved and Issued by Project in charge
Name		
Date		
Signature		



Quality Assurance Plan

CONTENTS

L&T - IHI CHENNAI (INDIA) CONSORTIUM

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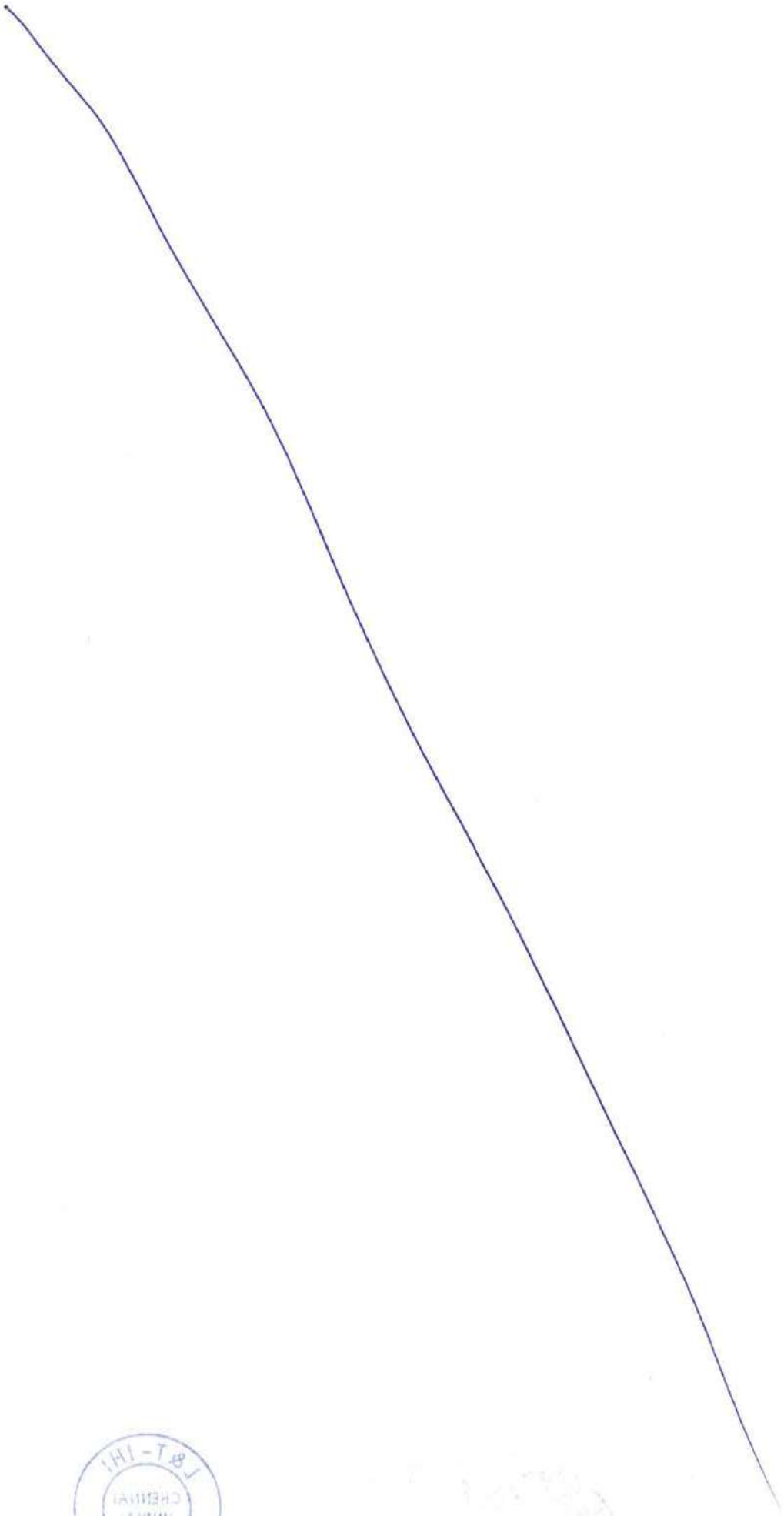
Quality Assurance Plan

S.NO	PROCEDURE NO.	CLAUSE NO	PROCEDURE DESCRIPTION
		PQP Work Procedures	
1	PQP WP 01	5.1,6.2,10.3	QMS Planning
2	PQP WP 02	6.2,7.5.1,7.5.2,7.5.3,8.2.1,8.2.4,8.5.6	Control of Documented information
3	PQP WP 03	7.5.2,7.5.3,8.1,8.2.4	Control of Records
4	PQP WP 04	5.3	Organization Chart
5	PQP WP 05	5.1,6.3,7.1.1,8.2.4,8.5.6,9.1,9.3	MRM
6	PQP WP 06	7.1,7.2	Human Resource And Training
7	PQP WP 07	7.1,8.1,9.1	Project Planning And Monitoring
8	PQP WP 08	8.2.4	Contracts Management
9	PQP WP 09	8.1,9.1,	Mobilization Review And Monitoring of Project
10	PQP WP 10	8.4	Selection Of Vendor, Procurement
11	PQP WP 11	6.1,10.2,10.3	Risk Management
12	PQP WP 12	8.5.2	Identification Traceability
13	PQP WP 13	8.5.4	Preservation, Handling And Storage
14	PQP WP 14	7.1.5	Calibration Of Measuring Test Equipment
15	PQP WP 15	5.1.2,7.1,8.2.1,10.2,10.3	Customer Feedback
16	PQP WP 16	9.2,10.3	Internal Audit
17	PQP WP 17	8.1,8.4,8.5,8.7,9.1,10.2	Inspection And Testing And Control of Non-Conforming Products
18	PQP WP 18	9.1,10.2,10.3	Corrective Action Procedure
19	PQP WP 19	-	Cancelled



Quality Assurance Plan

S.NO	PROCEDURE NO.	CLAUSE NO	PROCEDURE DESCRIPTION
20	PQP WP 20	9.1.3	Analysis Of Data
21	PQP WP 21		Interface management
22	PQP WP 02 WI 01	7.5	File list - Documents
23	PQP WP 02 GL 01	7.5	Handing over of Documents
24	PQP WP 03 WI 01	7.5	File list - Records
25	PQP WP 02 WI 02	7.5	Instruction for preparation of Method Statements
26	PQP WP 10 GL 01	8.4	Guidelines for Sub-Contractors Performance

S. NO	PROCEDURE NO.	CLAUSE NO	PROCEDURE DESCRIPTION
PQP Formats			
1	-	-	QMS Format index
2	-	-	QMS Formats

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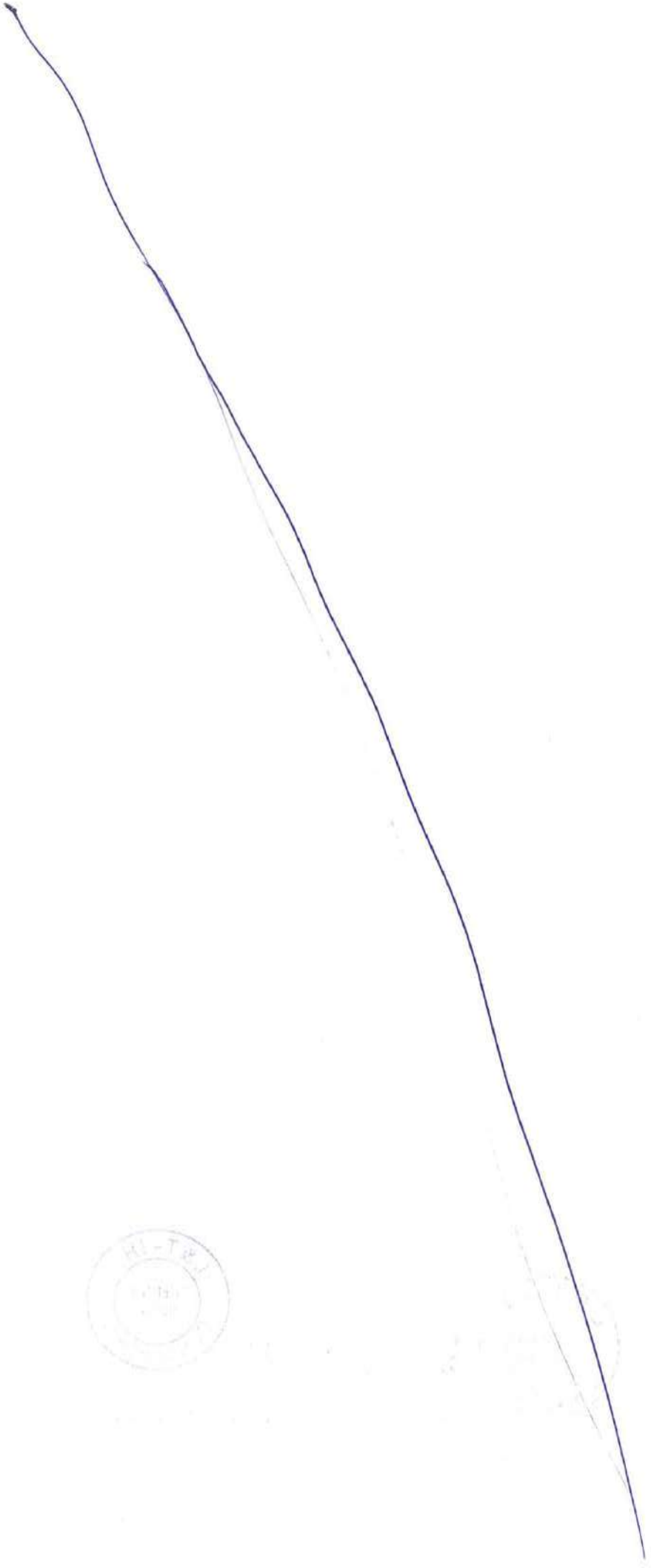
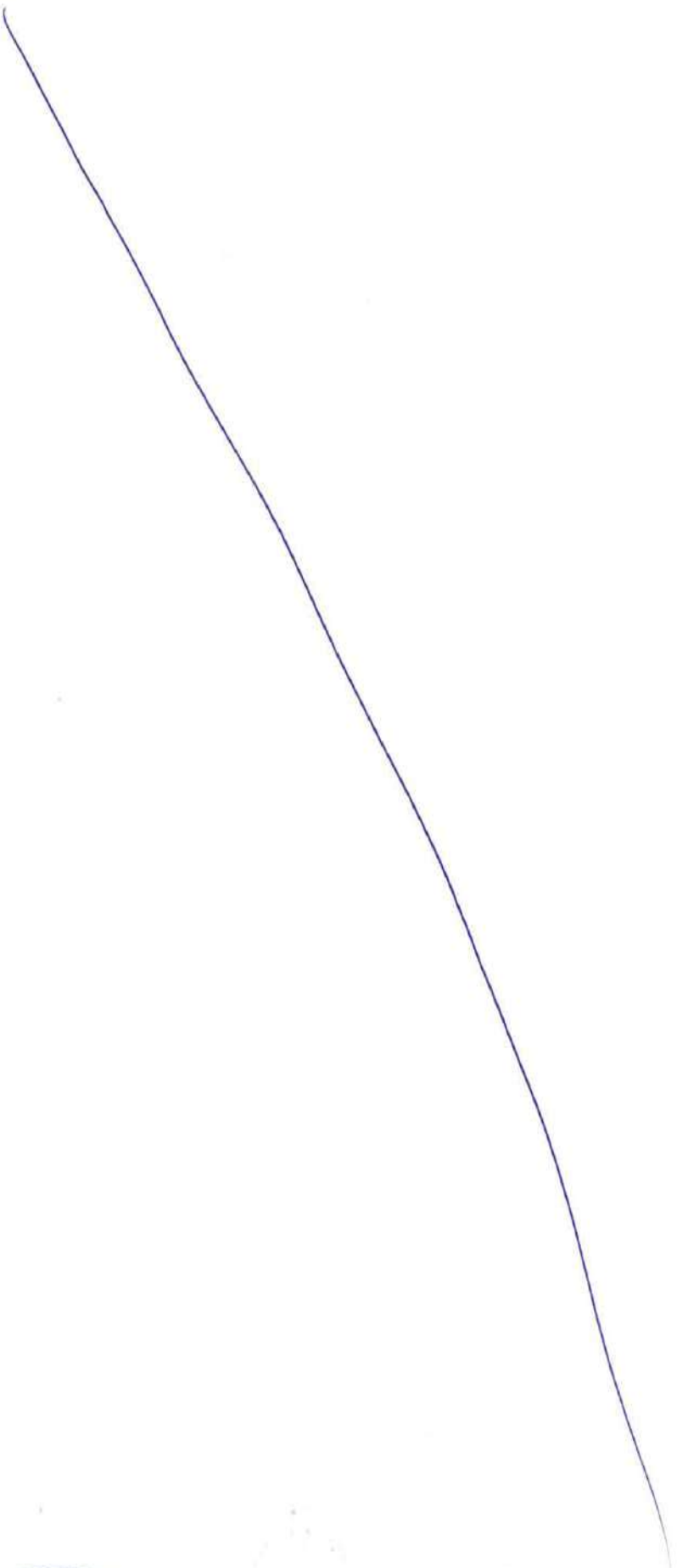


PROJECT QUALITY PLAN

DECLARATION

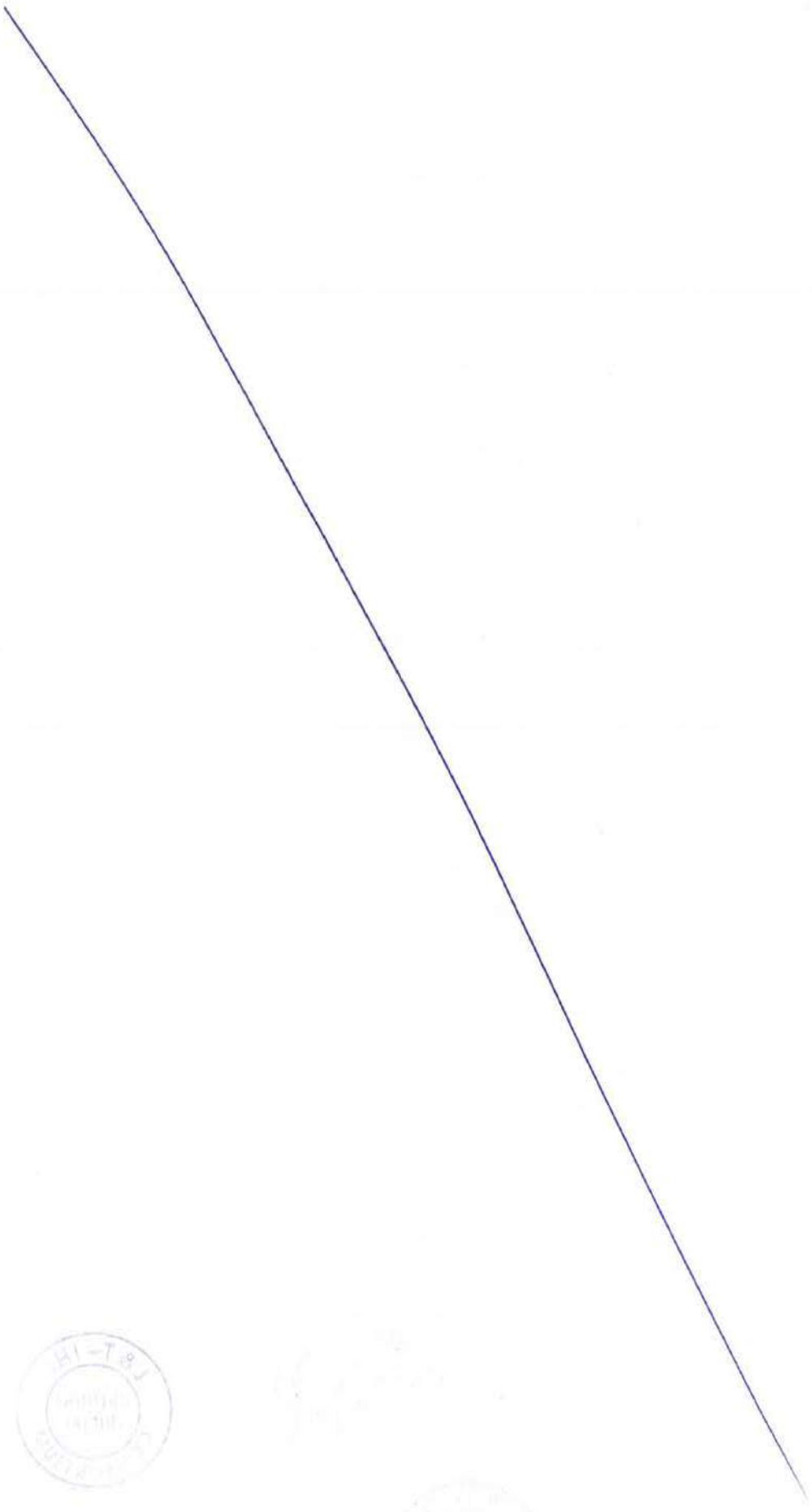
ABBREVIATIONS

ACE	Accepted Cost Estimate
CA	Corrective Action
CM	Construction Manager
CMPC	Construction Methods & Planning Cell
CAD	Command Area Development
EIP	Enterprise information Portal
HQ	Head Quarters
HR	Human Resource
HSE	Health Safety & Environment
ITP	Inspection and Test Plan
L&T	Larsen & Toubro Limited
IHI	IHI Infrastructure Systems Co., Ltd
MPCS	Management Planning & Control Systems



Quality Assurance Plan

NCR	Non Conformity Report
P&M	Plant & Machinery
PA	Preventive Action
PE	Planning engineer
PI	Project In-charge
PM	Project manager
PMS	Performance management system
PPE	Personal Protective Equipment.
QAP	Quality Assurance Plan
QA	Quality Assurance
QC	Quality Control
QMC	Quality Management Coordinator
QMS	Quality Management System
S/C	Sub-Contractor
PQP	Project Quality Plan
SA	Site Accountant
TC	Test Certificate
IC	Independent Company
EDRC	Engineering Design & Research Centre
EHS	Environment, Health & Safety
MIS	Management Information System
MRM	Management Review Meeting
HQ	Head Quarters
WO	Work Order
PO	Purchase Order

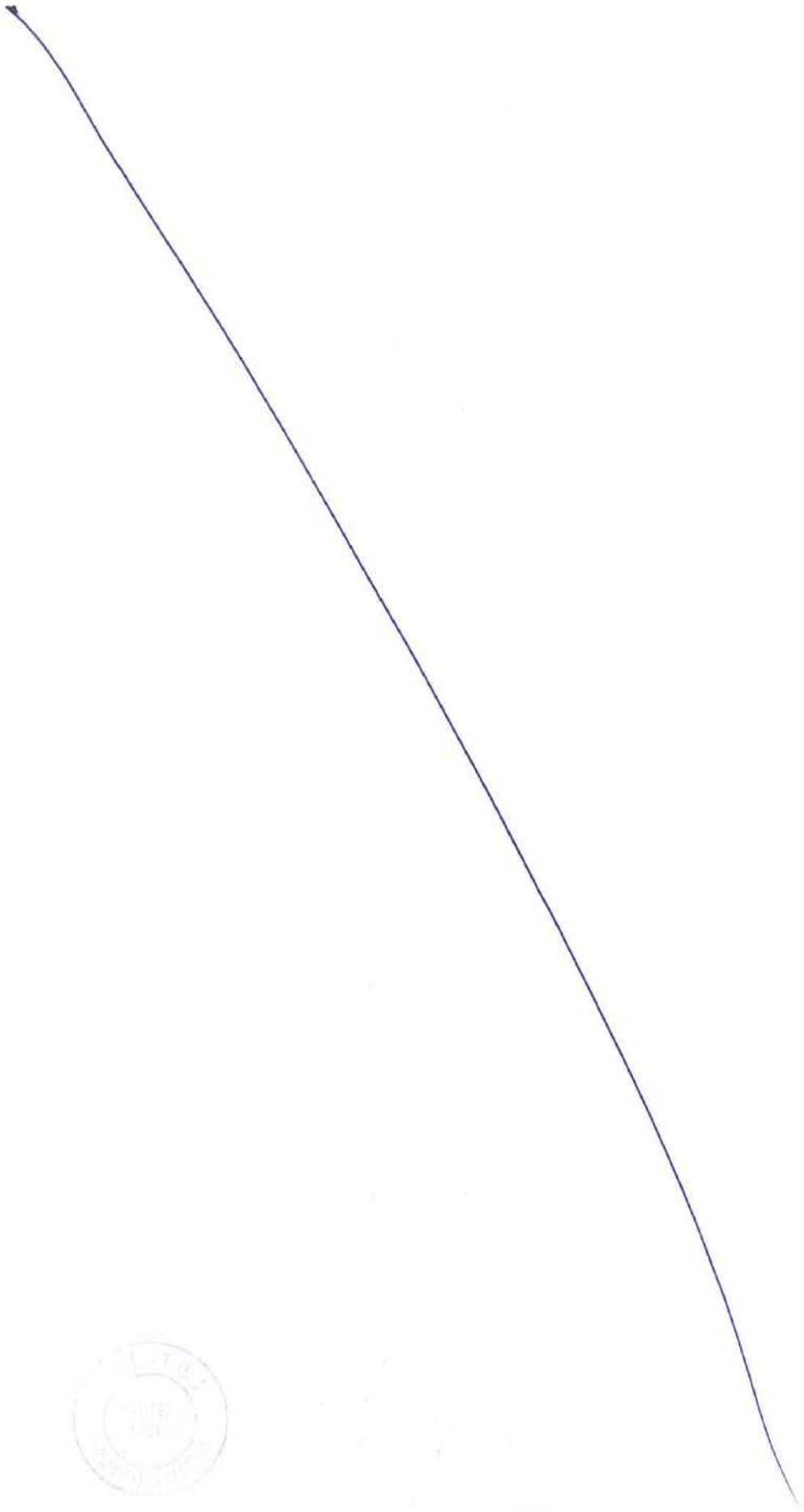


SCOPE, PURPOSE AND TERMS & DEFINITIONS

1.0 SCOPE :

a)	PROJECT TITLE	: Mumbai Trans Harbor Link Package 1
b)	PROJECT SITE LOCATION	: Mumbai
c)	CUSTOMER	: MMRDA
d)	CONSULTANT	:
e)	CONTRACTOR / ORGANISATION	: L&T-IHI Consortium
f)	SCOPE OF PROJECT AS PER CONTRACT	:
g)	CONTRACT AGREEMENT No AND DATE	:
h)	CONTRACT VALUE	:
i)	CONTRACT DURATION	:
j)	PROJECT START DATE	:
k)	PROJECT END DATE	:

2.0 PURPOSE:



2.1 This Project Quality Plan (PQP) is prepared and formulated as a Management Summary of Quality related activities required to meet the terms of contract. This Quality plan sets out the Management practices and describes the Quality Management System in consistent with Corporate Quality Documented Information of L&T-IHI Consortium.

2.2 This PQP is applicable to all activities in MTHL Project of L&T-IHI Consortium.

2.3 Reference and Applicable Documents

The following documents are used as a source of reference for preparation of this Project Quality Plan:

- Contract Documents & Drawings prepared / Issued by the Customer/ Customer's consultant
- Codes of practices as listed in drawings and specifications above.
- L&T-IHI Consortium Model Project Quality Plan.
- ISO 9000-2015 – Quality Management system – Fundamentals & vocabulary.
- ISO 9001-2015 – Quality Management system – Requirements.

3.0 TERMS & DEFINITIONS

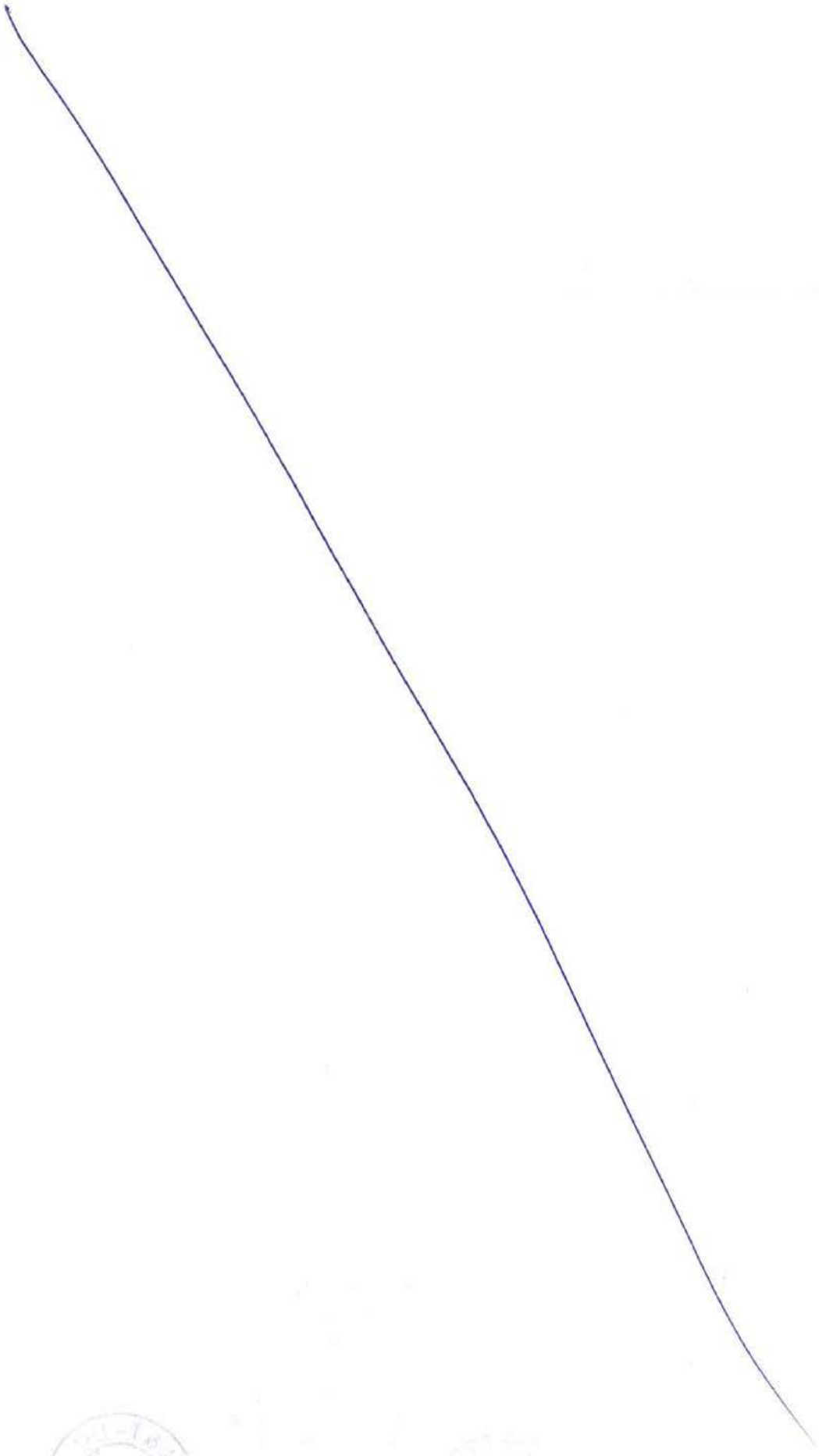
The following abbreviations or phrases shall mean as below:

Audit: A systematic, independent and documented process for obtaining audit evidence and evaluating it objectively to determine the extent to which audit criteria are fulfilled.

Authorized inspection agency: A service provided by any recognized independent agency and approved by the customer for employed by the customer for inspections and tests whenever required by the customer or his representative.

Check: A stage in the production cycle, when a third party Inspector or L&T-IHI Consortium representative performs a check or test to determine the acceptability of the item for further processing.

Concession: A formal approval by an appropriate agency, in this case the Customer or his authorized representative, to deviate from the specification or design which does not affect the final function.



Quality Assurance Plan

Controlled copy: Latest copy issued to users by Master Copy Holder with a control.

Corrective Action: An activity, the intention of which is to return the non-conforming item or action to a stage of conformity. It also covers the action taken to prevent further recurrences of non-conformity.

Customer: Government of Telangana, Irrigation & CAD Department.

Client/Customer Representative: Project in charge of the customer.

External Provider: Any person, firm or Company appointed by the customer directly or through L&T-IHI Consortium to provide service in the execution of the project.

Hold Point: Witness is mandatory before proceeding to further activities. The activity shall be kept under hold till inspection clearance or written waiver is obtained from the agency responsible for this stage.

Inspection: Activities such as Measuring, Examining, Testing, Gauging one or more characteristics of a material, documented information, product or service and comparing this with the specified requirements.

Master copy: Original / first copy received or generated at site

Quality: Degree to which a set of inherent characteristics fulfils requirements.

Quality Assurance: Part of Quality Management focused on providing confidence that Quality requirements will be fulfilled.

QAP: Quality Assurance Plan also means QPs (Quality Plans) mentioned in contract document. The term ITP (Inspection Test Plan) is also used interchangeably with QP/QAP in this PQP.

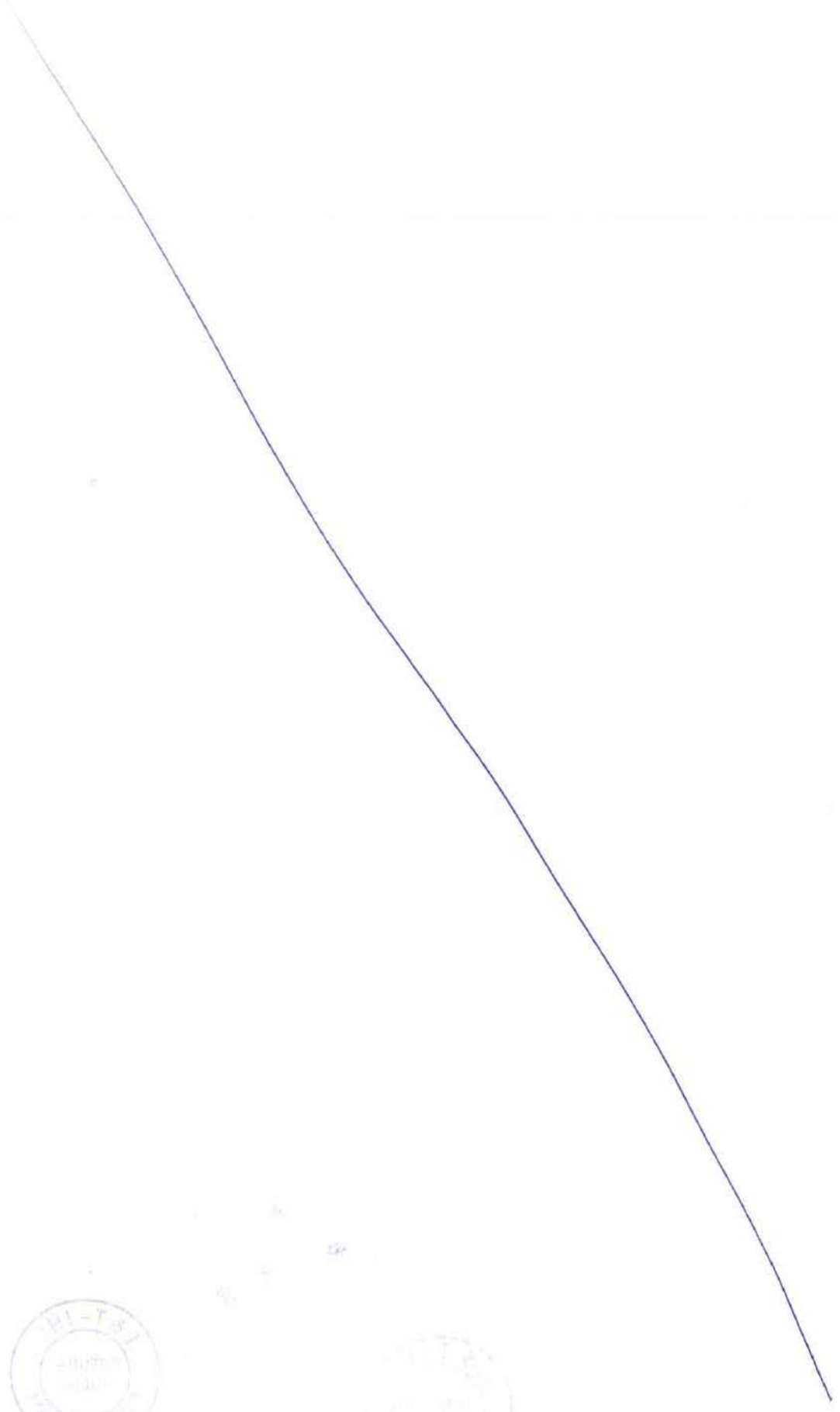
Quality Control: Part of Quality Management focused on fulfilling Quality requirements.

Project Quality Plan: An apex level document at project site specifying which documented information and associated resources shall be applied by whom and when to a specific project, product, process or contract.

Organization Representative: Project in-charge of the contract for L&T-IHI Consortium.

Procedure: Specified way to carry out an activity or a process.

Project In-Charge: Project head designated by L&T-IHI Consortium (Also called as Project Director)



Repair – The process of restoring a non-conforming condition such that the item conforms to the original specified requirements, where such a repair or restoration is acceptable.

Review: A stage in a construction cycle, when a third party Inspector or THIS Project representative may verify records and or documented information and determine the acceptability of the same.

Site Management: The team comprising of Project in-charge, Planning Manager, Accounts & Administration In-charge and the concerned Department Heads.

Third party inspection: A service provided by any recognized independent agency employed by the Customer or by L&T-IHI Consortium to oversee inspections and tests for materials whenever required by the customer or his representative.

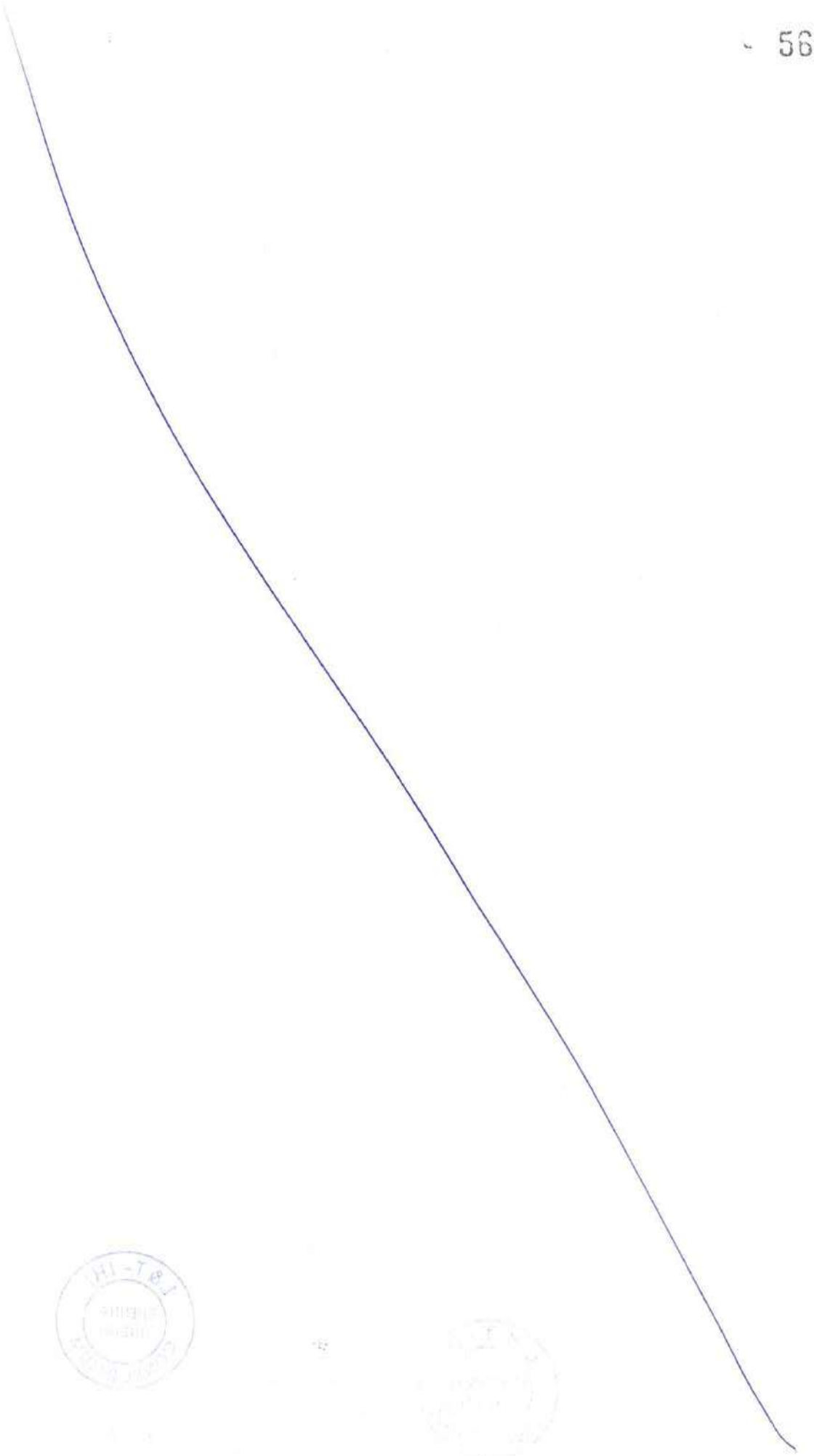
Uncontrolled copy: One time copy issued for reference or any other purpose without any control.

Witness point: A stage in the production cycle when a third party inspector, contractor or company representative witnesses any inspection and or test to determine the acceptability of an item for further processing. In this case, the performer of the activity informs the inspector/inspection agency in advance to witness the activity, but there is no hold on work if inspector is unavailable to witness.

4.0 CONTEXT OF THE ORGANIZATION

4.1 Understanding the organization and its context

L&T-IHI Consortium has determined internal and external issues that are relevant to its purpose and its strategic directions. MTHL Project shall gather and monitor the issues relevant to project as indicated below:



Sl.No	Subject	Issues
1	Customer related	Overall project status and issues faced by customer , issues from previously completed projects
2	Manpower related	Issues related to labor availability and issues related to staff competency /availability
3	Technology related	Any new technology desired by customer
4	Social & Cultural	Recognition , feedback from public & Customer
5	Grievances	Customer complaint.
6	Legal	Fulfilling the statutory & regulatory requirements and consequences of non-fulfillment

This information is shared with Head Office through verbal, e-mail, letters and meetings.

4.2 Understanding the needs and expectations of interested parties

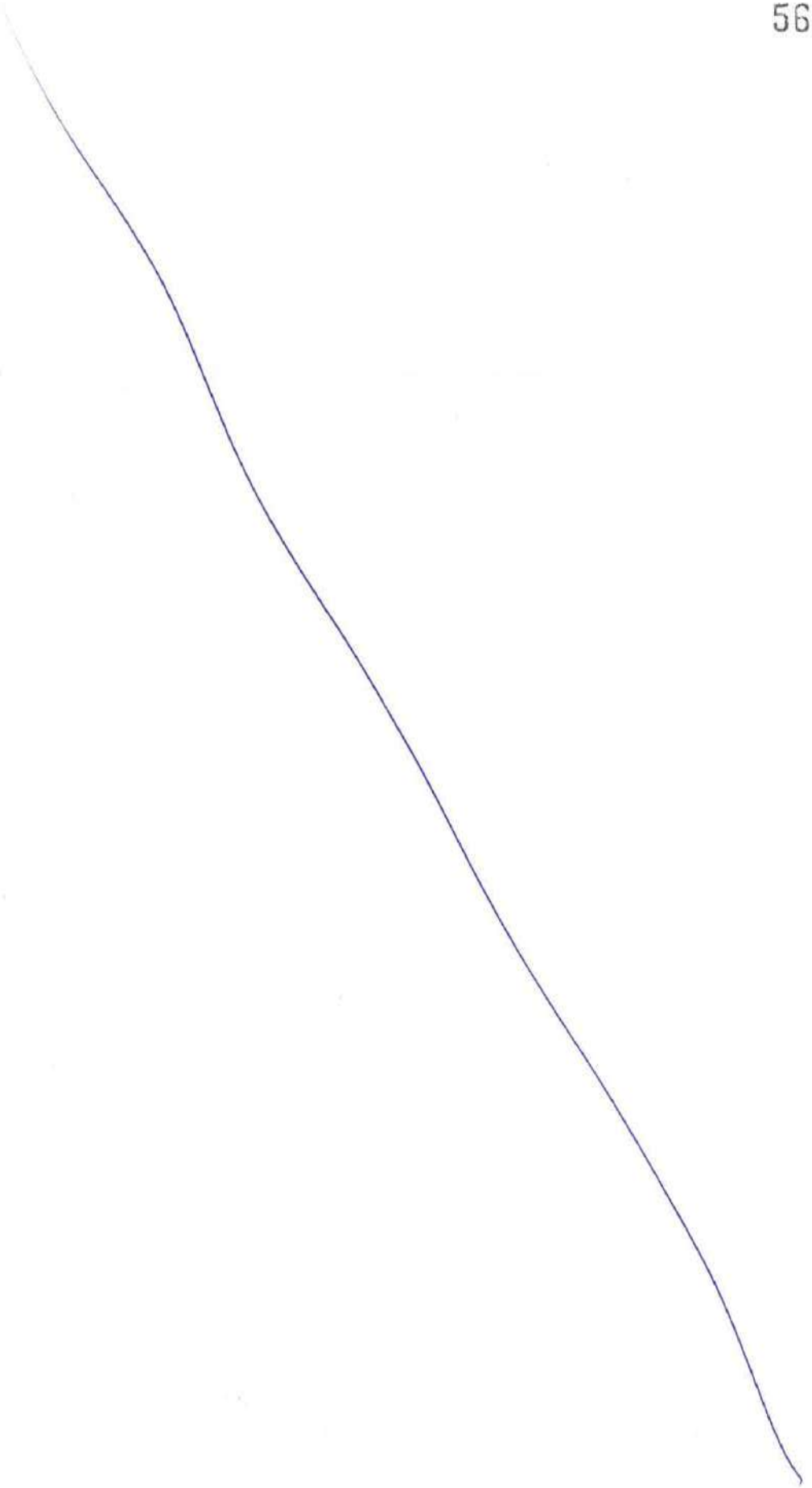
L&T-IHI Consortium has determined to identify the interested parties and their requirements relevant to its business and the same is ensured while strategy finalization. Outcome of these are shared to project site as applicable. The following requirements have been identified for the interested parties relevant to this project:

Sl.No	Type	Interested parties	Requirements/expectations
1	External	Customer	Project completion in time with safety & quality
2	External	External providers (Sub contractors, suppliers etc.)	Clarity in specification, Timely inspection, timely clarification, continuous availability of works, repeat orders etc.
3	External	Statutory & regulatory bodies	Compliance to the requirements
4	External	Public	Social welfare, Control disturbance to values and culture.
5	Internal	Employees	Welfare, Competency and Training

Any changes in the needs & expectations of interested parties shall be reviewed and suitable strategies shall be established.

4.3 Determining the scope of the quality management system

MTHL Project has well defined the scope of its quality management system to cover the entire scope of the contract. The scope of this Project is stated as below:



The following are the functions relevant to successful execution of the MTHL Project and covered in the QMS scope.

- **Project management**
- **Design * (Delete if not applicable)**
- **Planning**
- **Execution**
- **Quality Assurance & Quality control**
- **Stores**
- **Plant & Machinery***
- **Safety***
- **Accounts & Admin**

*- *Department specific processes are covered by exclusive documented information as listed below and maintained by respective in charges as required:*

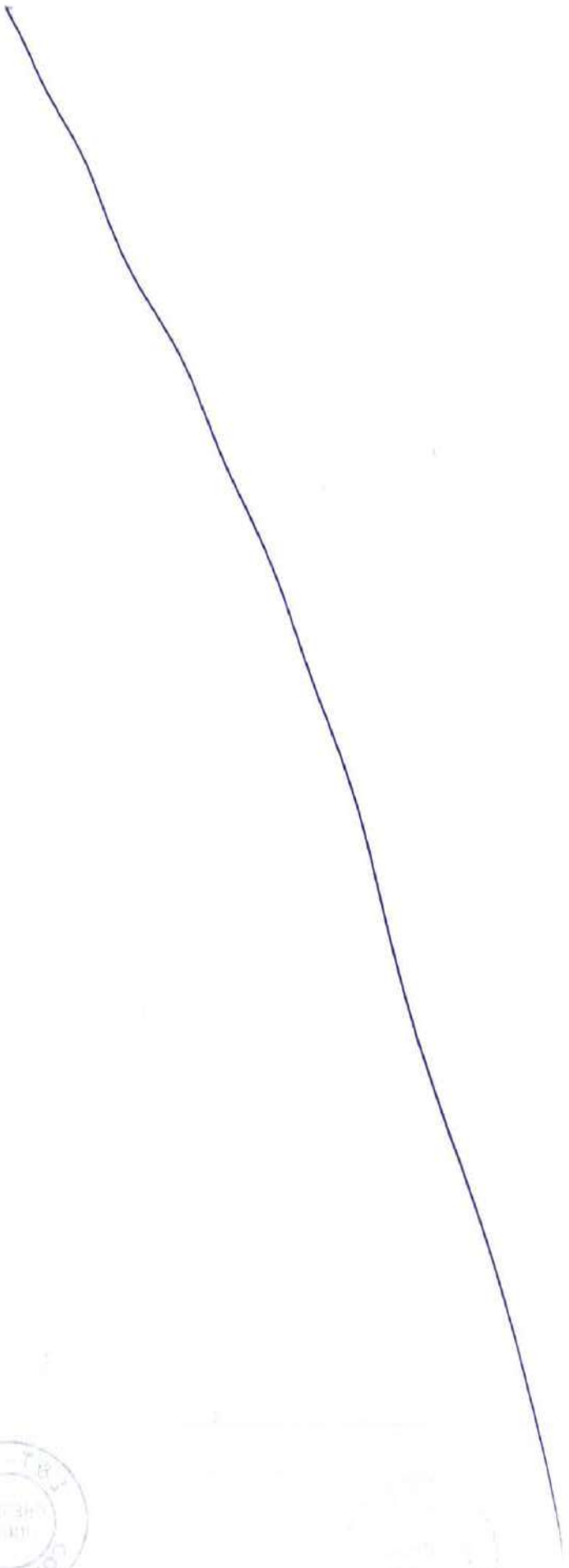
Design	*– EDRC Quality Manual (Delete if not applicable)*
Plant & Machinery	*– P&M Quality Manual*
EHS	*– EHS Quality Manual*

Scope of QMS for this project covers the external providers. (E.g. specialized agencies/ vendors, & outsourced design services.
Refer the format **HCI IC/PQP 4.3 F 01** for complete scope of QMS applicable to this project.

4.4 Quality management system and its processes

This Project has a well-established and documented Quality Management System (QMS) and takes appropriate steps to improve its effectiveness in accordance with the requirements of ISO 9001:2015.

Relevant documented information established clearly specifies the criteria and methods for effective operation, monitoring and control. Necessary resources and information to support the operation and monitoring of these processes are established.



a) This Project has established documented information for monitoring, measuring and analyzing these processes and to take necessary actions to achieve planned results and continual improvement of these processes. It has also maintained relevant documented information to identify and exercise required control over external provider processes, if any (Fig. 4.4)

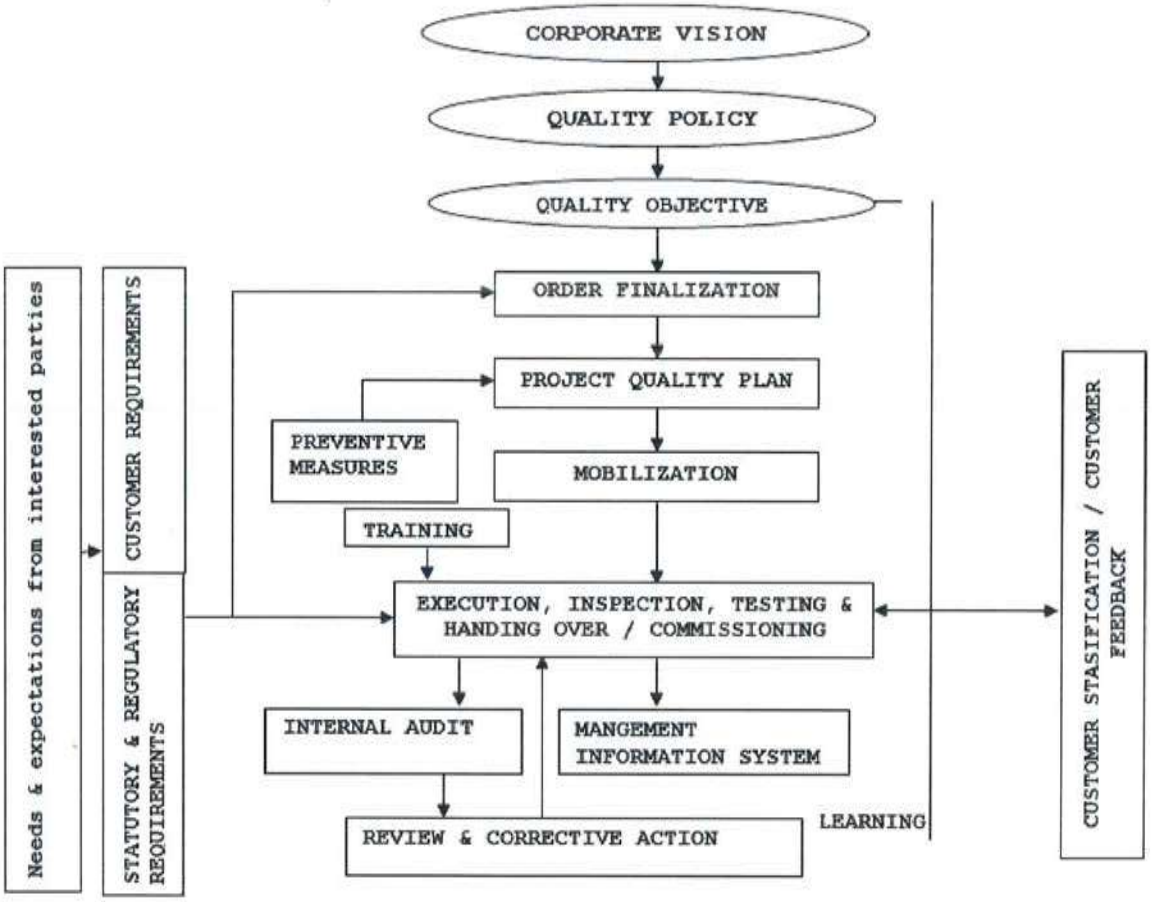
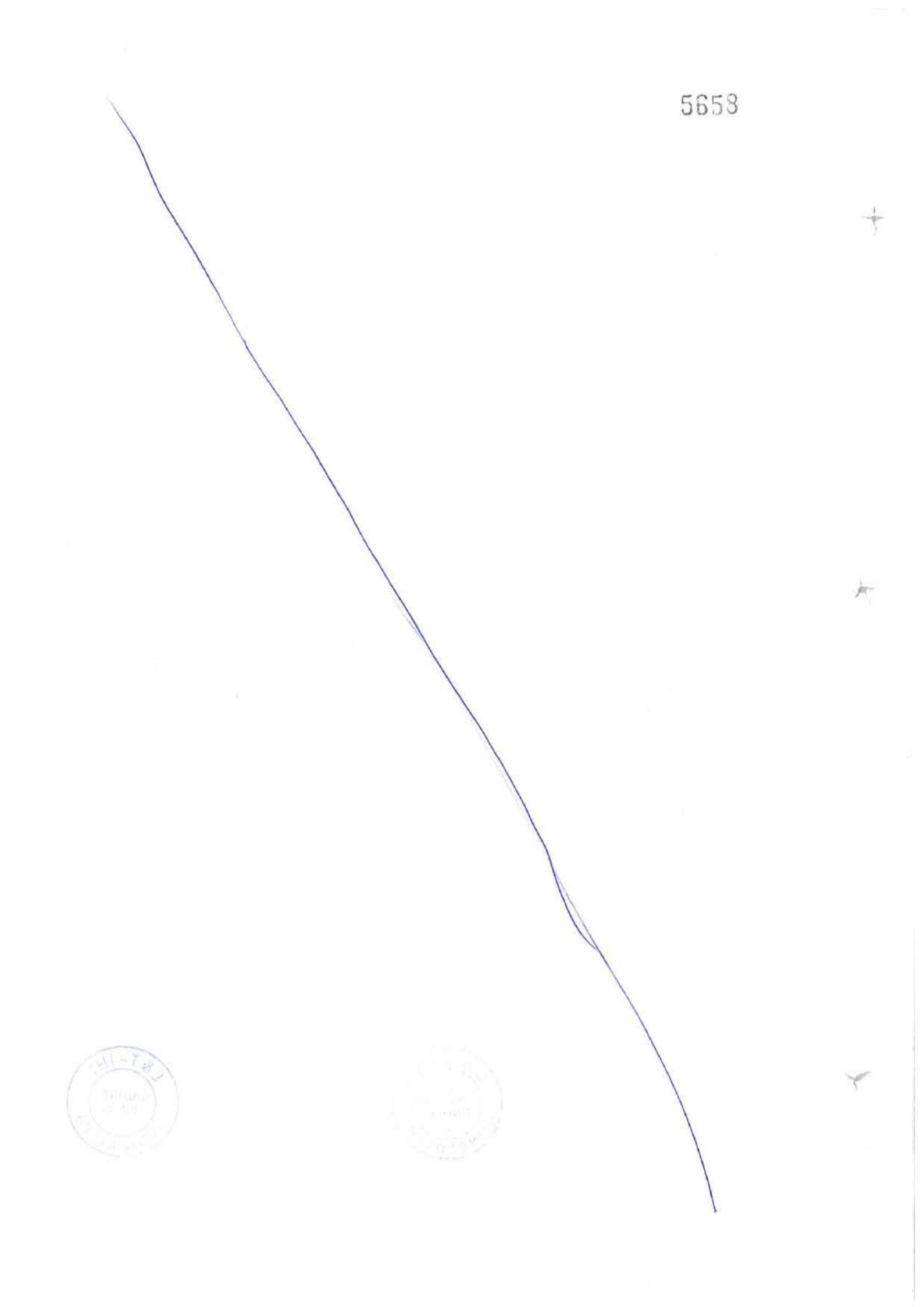


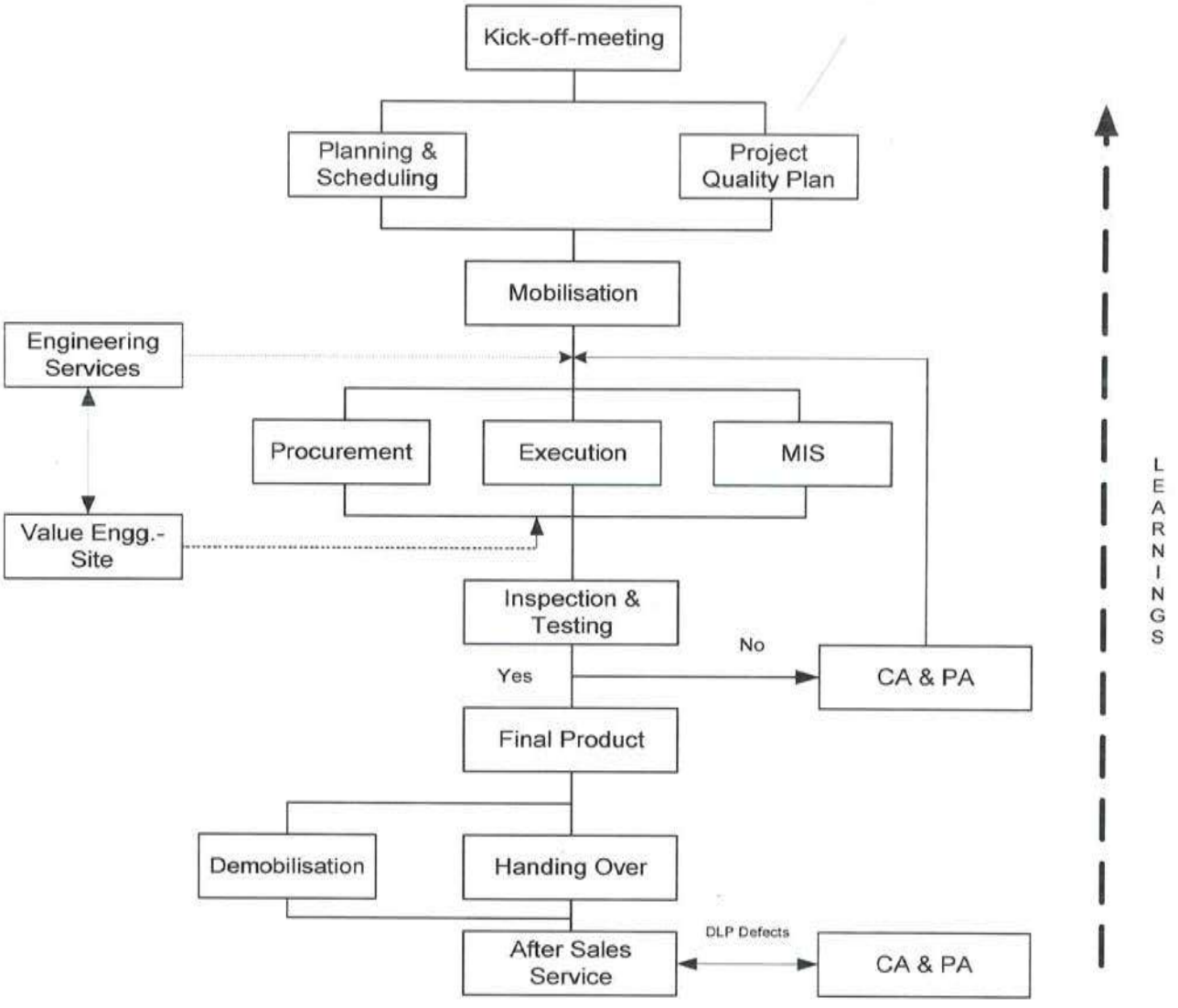
FIG. 4.4: PROCESS FLOW CHART

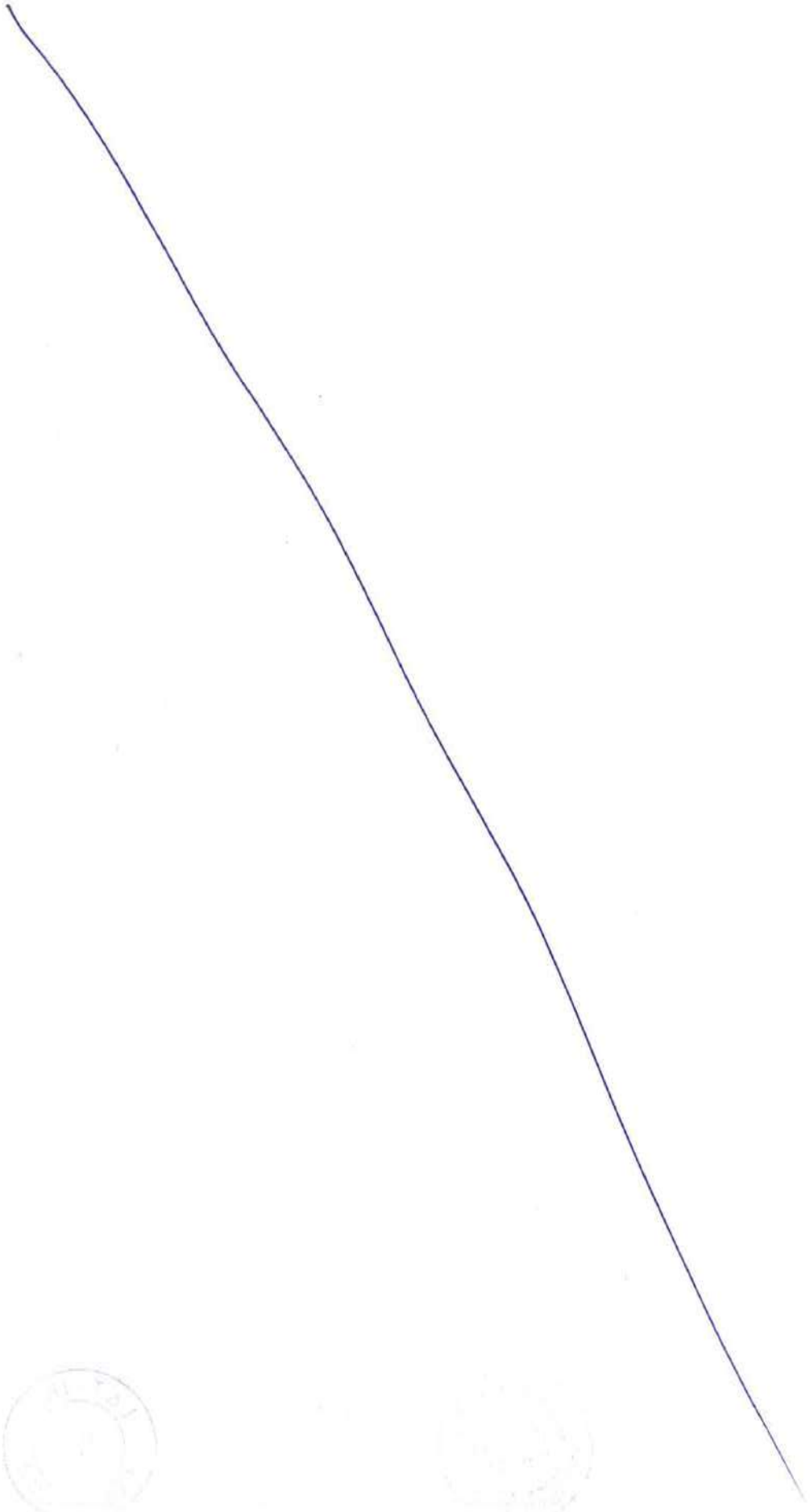


Quality Assurance Plan

PROCESS MAPPING FOR SITE OPERATIONS

Site Process





b) Project specific organization chart is detailed in **PQP WP 04**. The responsibilities and authorities for each function are defined. These include planning, operations, control, review and monitoring and corrective actions as appropriate for respective functions. Effectiveness of the quality management system is evaluated through review meetings at various levels and course correction made accordingly.

c) This Project has established and implemented the documented Information for Resources management. Well-established systems exist for acquisition, monitor & control of effective utilization of the resources.

d) MIS is the tool used in organization for systematic data collection and reporting. This data is used to analyze, review and monitor This Project at different levels and reviewed by Management.

e) Responsible persons execute as per documented plan; Results are measured against targets set. Performance measurement aims at continual improvement.

Wherever the processes are externally provided for some specific products, those are controlled in accordance with the documented Quality Management System.

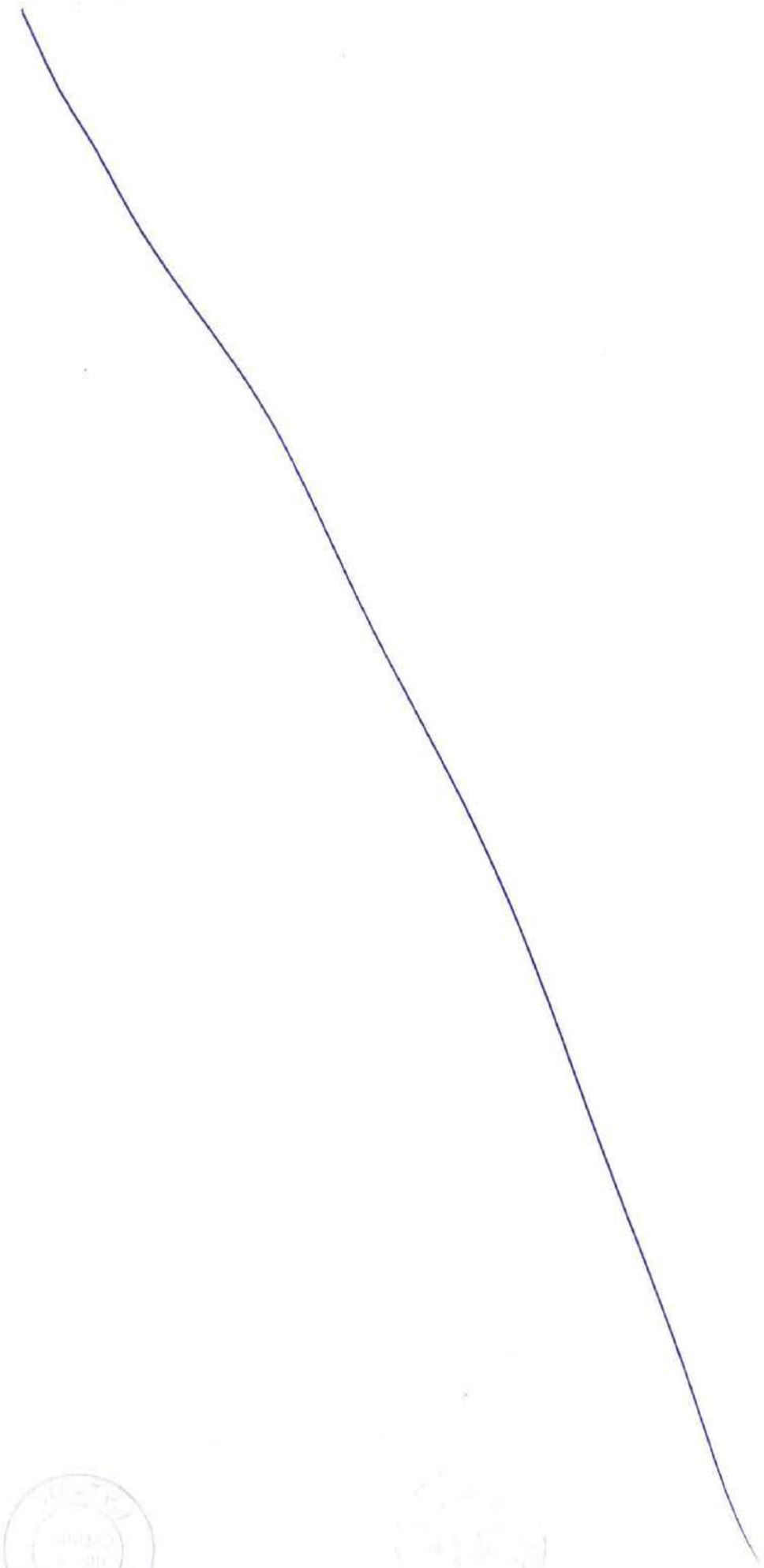
5.0 LEADERSHIP

5.1 Leadership and commitment

5.1.1 General

L&T-IHI Consortium has common direction - a shared understanding of goals and values - constantly interacts to go beyond individual expertise to solve complex problems and regularly updates to expand capabilities in response to change.

The leadership (including Project in-charge) holds key positions at HQ, Cluster offices and Sites in a matrix organizational structure. Management has identified a QMS coordinator for effective implementation and monitoring of QMS throughout organization. Management Reviews are planned at various levels for effective monitoring of QMS.



Reference procedures:

1. Procedure for planning of QMS & Quality objectives – PQP WP 01
2. Procedure information for Management Review – PQP WP 05

5.1.2 Customer Focus

Processes are established for customer communication on suggestions for improvements, information on status and meetings. Areas of dissatisfaction / improvements, if any, are discussed at various levels and informed to this Project and corrective actions shall be taken based on above inputs.

During the execution, the customer interaction is on a continuous basis and the requirements are met on regular basis as per PQP. The Customer complaints received at this Project shall be mitigated through established procedure **PQP WP 15.**

The requirements related to this Project shall be determined as detailed in PQP/8.2 and are met with the aim of enhancing customer satisfaction as per PQP/ 9.1.

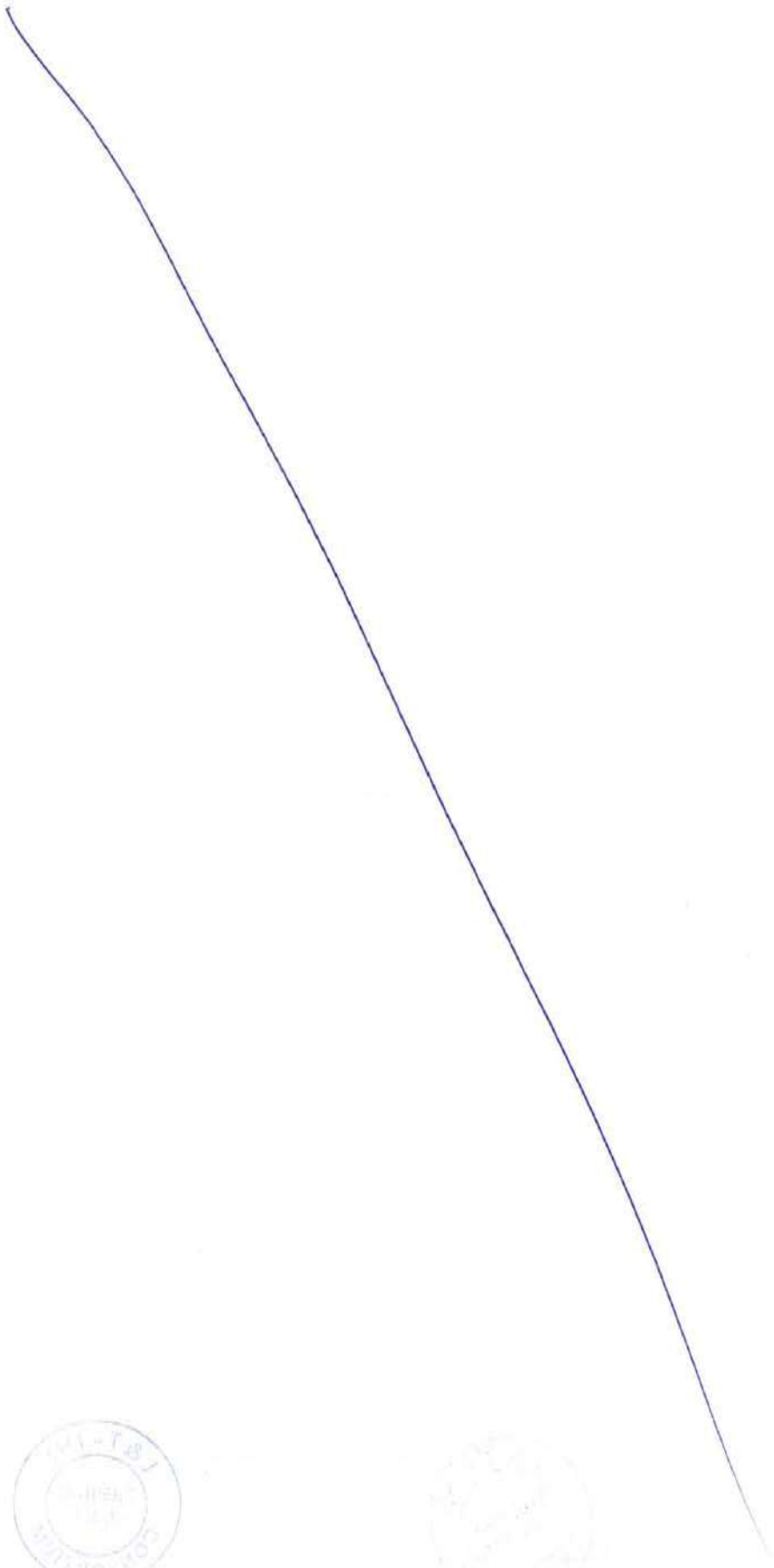
Reference procedures:

1. Procedure for Customer feedback - PQP WP 15

5.2 Policy

5.2.1 Establishing the quality policy

Top management has established, implemented, and maintained the quality policy based on the corporate Vision and Strategy. The Quality Policy is presented hereunder are the guiding force for all the process applicable across the organization including this Project.



VISION

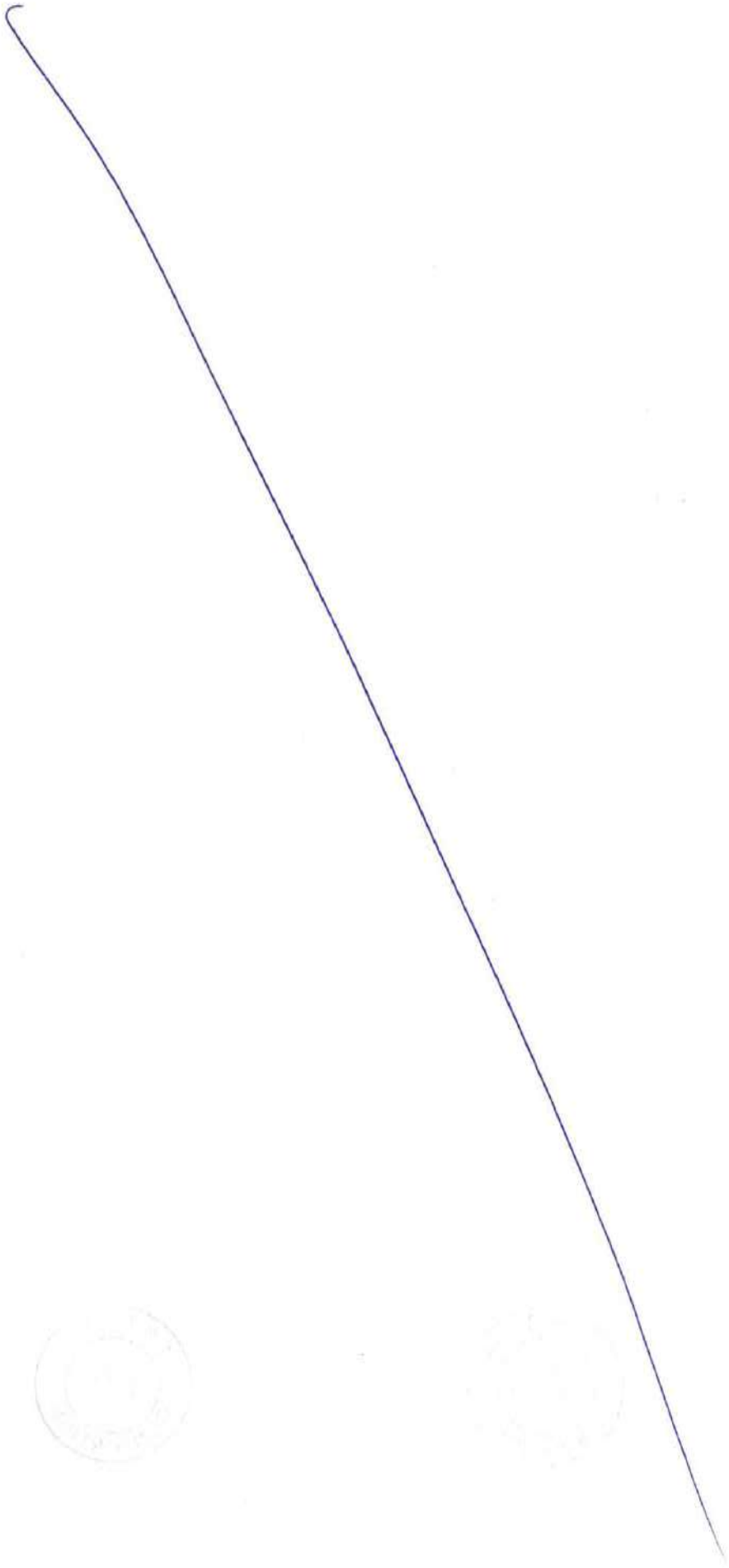
L&T shall be a professionally-managed Indian multinational, committed to total customer satisfaction and enhancing shareholder value.

L&T-ites shall be an innovative, entrepreneurial and empowered team constantly creating value and attaining global benchmarks.

L&T shall foster a culture of caring, trust and continuous learning while meeting expectations of employees, stakeholders and society.

LARSEN & TOUBRO

FIG. 5.2.1: L&T VISION



QUALITY POLICY

Sustainable Success ...

Larsen & Toubro Limited – Heavy Civil Infrastructure Independent Company is committed to achieve and sustain Business Excellence by integrating sound Quality Management principles into all its activities and at all levels of the organisation, considering the expectations and requirements of the interested parties.

We would operate with clearly articulated and aligned objectives, embracing the strategic direction of the organisation.

- Customer Focus: Enhancing Customer satisfaction by meeting customer requirements and striving to exceed expectations.
- Leadership: Develop leaders who set high expectations, serve customers, achieve Business Excellence and include sense of entrepreneurship and team spirit in the organisation: work together,take prudent risk,learn and continually improve performance.
- Engagement of People: Train, encourage and motivate people throughout the organisation to establish and meet both short-term and long-term commitments to all stakeholders including the society.
- Process: Manage work as a process with focus on results : improving efficiency , delivering enhanced value to customers and other stakeholders with risk-based thinking.
- Improvement : Install Plan-Do-Check-Act process at every stage of work to achieve both continual and breakthrough improvements in Quality, Safety, Cost and Time.
- Relationship Management: Build long-term relationship with the customer and all stakeholders based on shared objectives.

We would adopt a value-driven professional approach and ensure that the Quality Management System as per ISO 9001:2015 is effectively implemented and continually improved for achieving Excellence.

S.V.Desai
Executive Vice President & Head
Heavy Civil Infrastructure IC

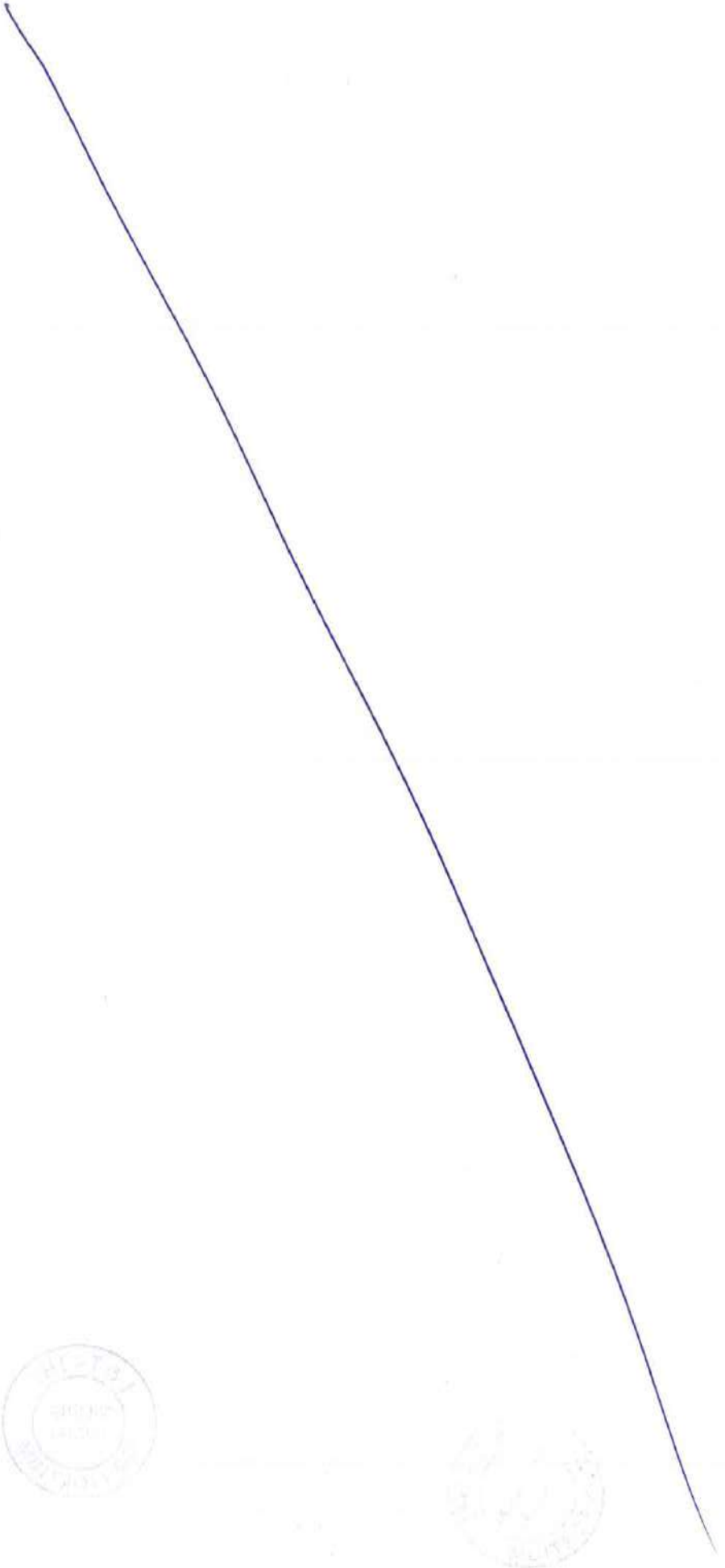
June 10, 2016

LARSEN & TOUBRO LIMITED
Heavy Civil Infrastructure Independent Company

FIG. 5.2.2: L&T-INFRA IC QUALITY POLICY

L & T - IHI CONSORTIUM CHENNAI (INDIA)

L&T - IHI CONSORTIUM CHENNAI (INDIA)



5.2.2 Communicating the quality policy

Quality Policy is maintained as documented information. And is communicated within the organization, ensured to understand and apply. The Quality policy is ensured to reach interested parties as appropriate.

5.3 Organizational roles, responsibilities and authorities

Organisation chart and functional responsibilities are shown in **PQP WP 04**.

Updating of organisation chart & responsibilities shall be done as and when changes are made (additions /deletions of functions) and maintained.

Project in-charge shall identify an alternate person with added responsibility, in case of a key staff is out of station (on duty) or on leave or released from site.

6.0 PLANNING

6.1 Actions to address risks and opportunities

Based on the issues of the interested parties (internal & external) and their needs & expectations as explained in clause 4.1 & 4.2,the following key areas are identified for addressing risk and opportunities:

a) Design & engineering risk (as applicable)
b) Contractual / legal risk
c) Execution risk
d) Commercial / financial risk

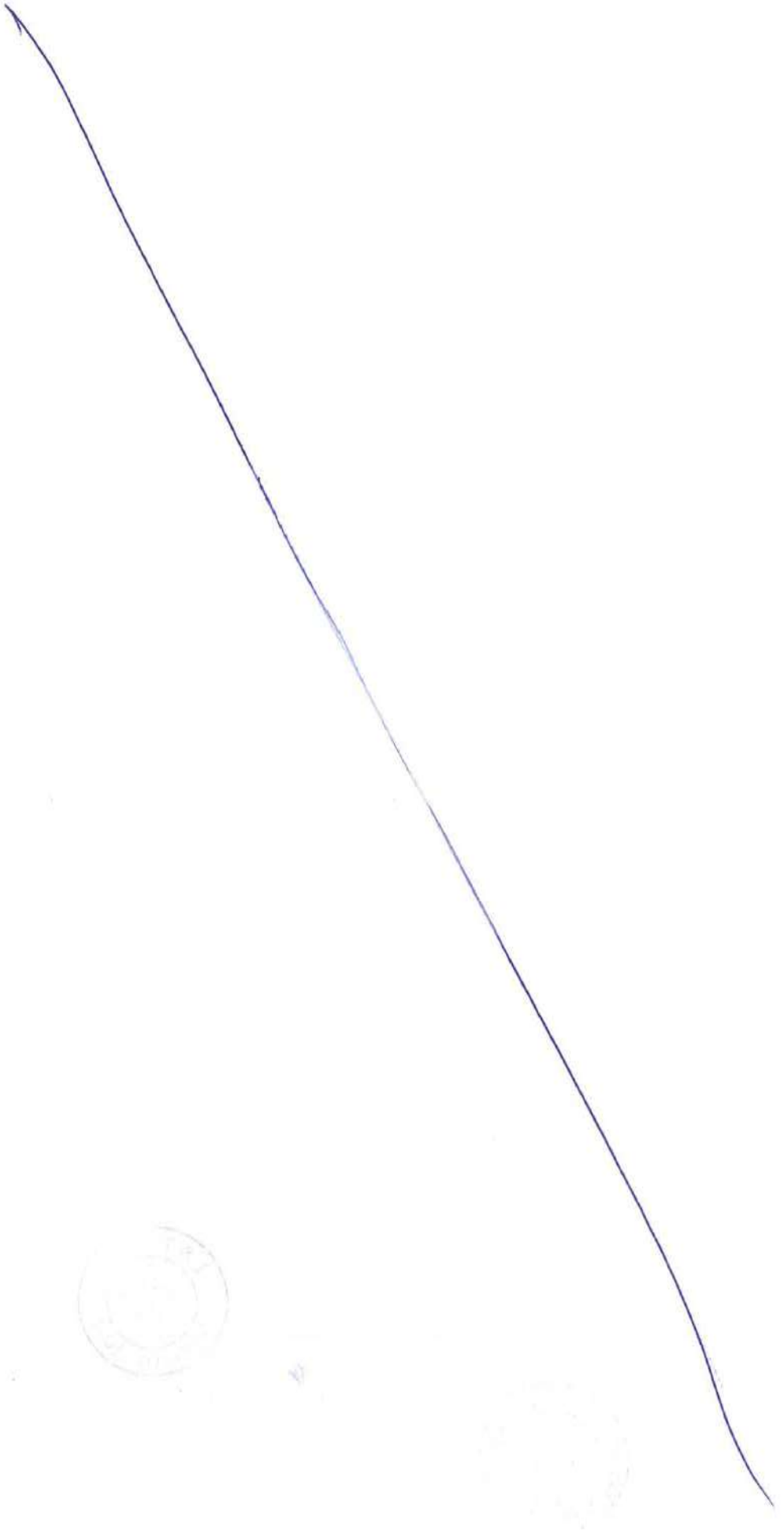
Any critical risks which may lead to delay or increase in cost shall be analyzed and addressed.

6.2 Quality objectives and planning to achieve them

a) Quality Objectives

The quality objectives are derived based on following:

a) Quality policy of the L&T-IHI Consortium



b) Identified internal and external issues and the requirements of relevant interested parties (refer clause 4.1,4.2)
c) Operations applicable at this Project

Various units / departments and individuals at functional level would derive list of objectives.

For this Project, the objectives are set at the time of project commencement. The progress is reviewed at site.

For each of the key position value drivers are defined, monitored and measured which adds up to the Quality objectives for the function. Similarly, the target objectives of a department / unit are attained through value drivers of the key positions.

Reference Procedures :

1.Procedure for planning of QMS & Quality Objectives - PQP WP 01
2. Procedure for control of Documented Information - PQP WP 02

b) Planning to achieve them

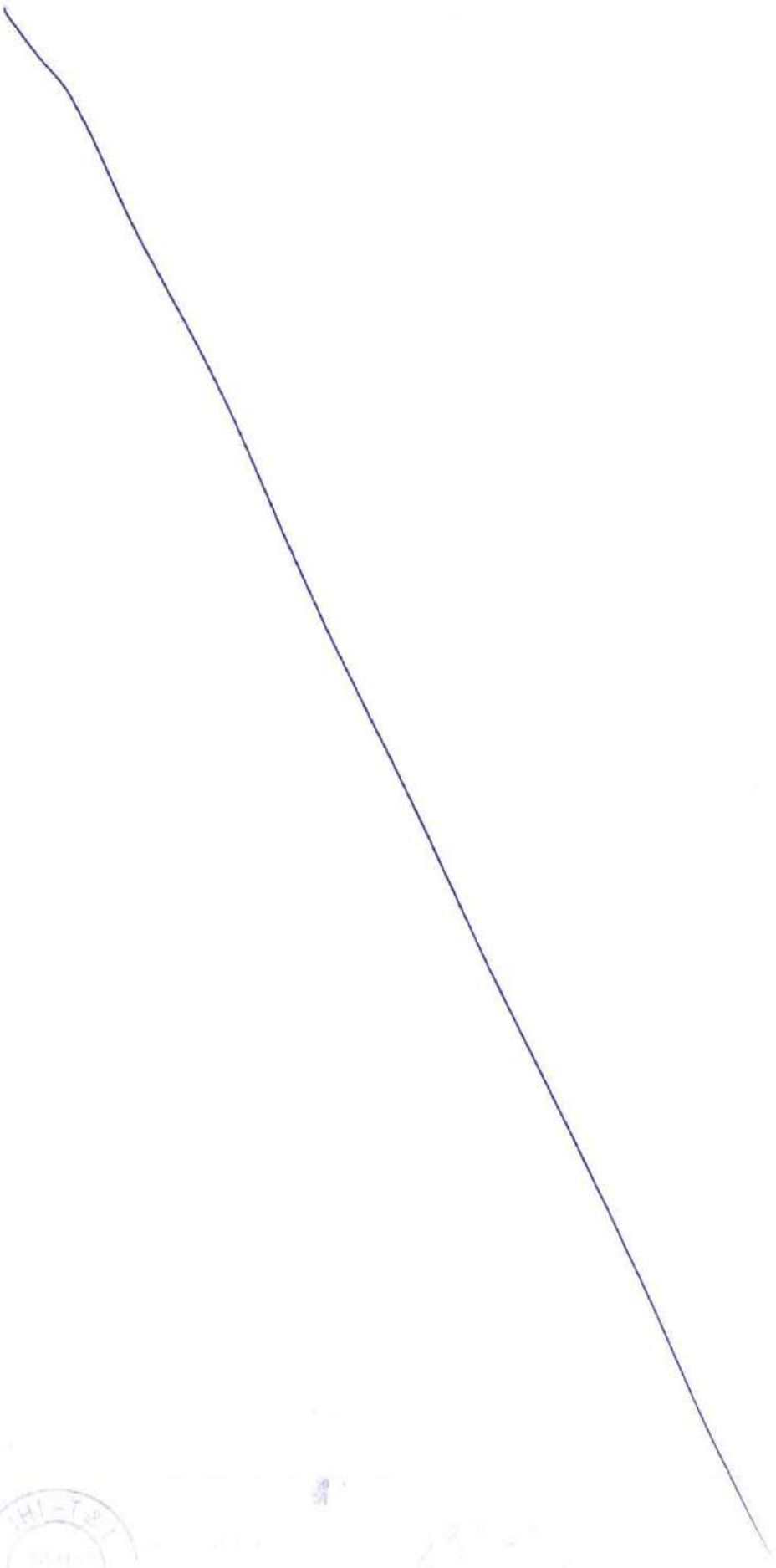
This Project has established and maintains a documented information for Planning of QMS & Quality objectives: which describes the identification of resources needed to achieve Quality objectives and providing the same. This also includes various processes of Quality Management System and continual improvement of QMS. Any changes in QMS due to Quality planning are carried out as per Procedure for document and data control.

Reference Procedures :

1.Procedure for planning of QMS & Quality Objectives - PQP WP 01
2. Procedure for Risk Management - PQP WP 11

6.3 Planning of changes

This Project has determined to bring the changes in the quality management system as and when felt for improvement based on audit result, customer complaints and changes directed by Consortium office.



While the changes are implemented project shall ensure that the changes are implemented in a planned manner (refer clause 4.4) considering

a) Potential consequences
b) Integrity
c) Availability of resources
d) Allocation or reallocation of responsibilities and authorities.

Reference Procedures:

1. Procedure for Management Review - PQP WP 05
2. Procedure for Audit - PQP WP 16

7.0 SUPPORT

7.1 Resources

7.1.1 General

This Project has established and maintains the documented information for identifying and providing resource required in time to implement and improve the processes of Quality Management System. Management also identifies and lists out the requirements of resource (capital items) while preparing for site requirement. Project in-charge reviews the resources requirements, arising out of project needs, customer feedback and satisfying customer requirements as part of review of quality system.

Reference Procedures:

1. Procedure for Project Planning & Monitoring – PQP WP 07
2. Procedure for Customer feedback – PQP WP 15
3. Procedure for Management Review – PQP WP 05

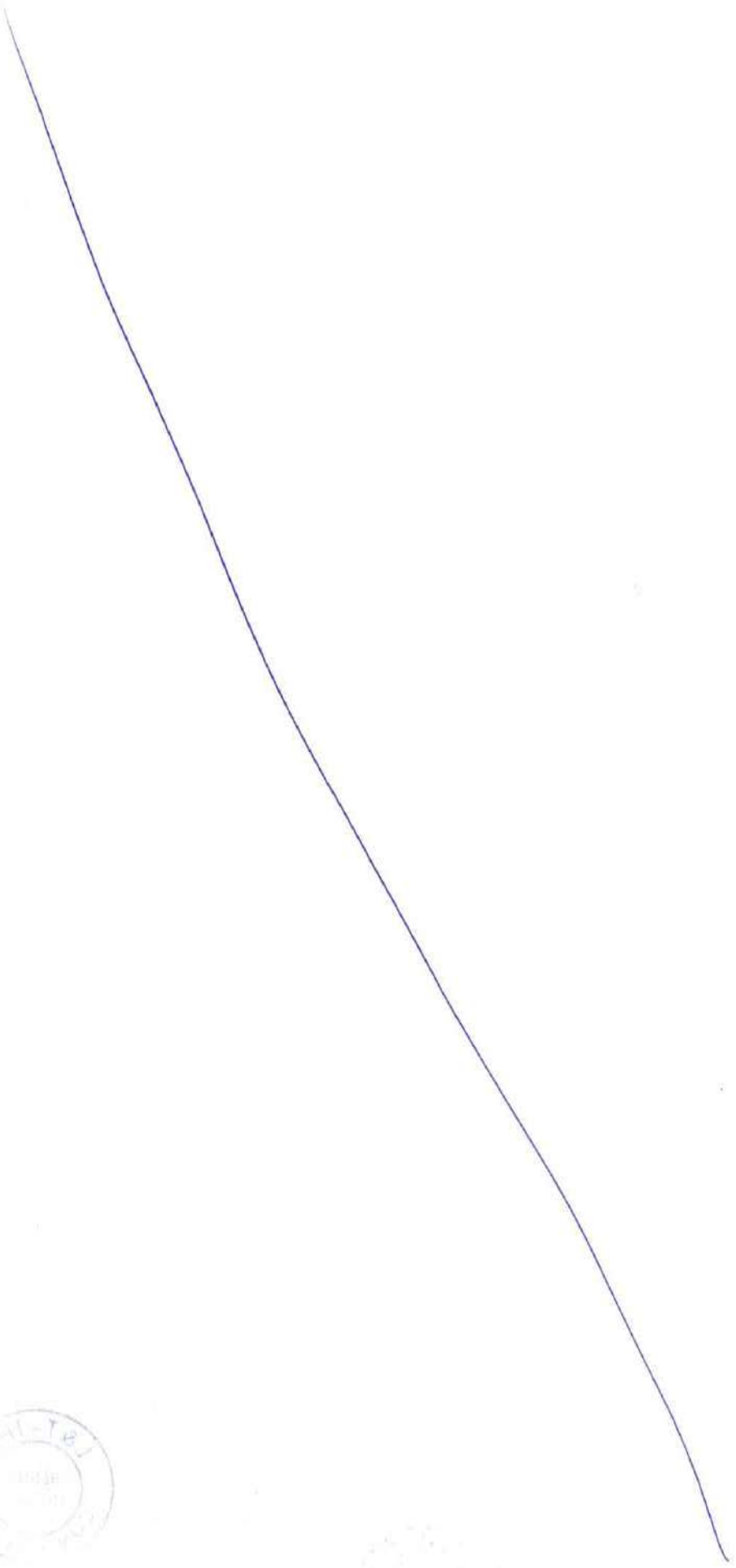
7.1.2 People

This Project has determined to provide Human Resources necessary for the effective implementation of its quality management system and for the operation and control of its processes.

Reference Procedures:

1. Procedure for Human Resources & training – PQP WP 06

7.1.3 Infrastructure



This Project provides the required infrastructure for effective & efficient Performance of the project.

These infrastructures include finance, workspace, utilities like water, electricity etc.

The resources such as manpower, Plant facility, transport, Communication needed to achieve required Product quality are provided. Management reviews these during budget and additions or modifications are carried out to meet the requirements of product and customer.

Reference Procedures:

1. Procedure for Project Planning & Monitoring – PQP WP 07

7.1.4 Environment for the operation of processes

This Project has established and maintains site Administration and it is guided by documented information for Time Keeping & Industrial Relations, EHS and HR.

It describes the welfare of staff and workmen, Medical insurance, Compensation, etc. as per company norms. Also EHS documented information describe the human and physical factors and provides work environment those needed for achieving conformity of products.

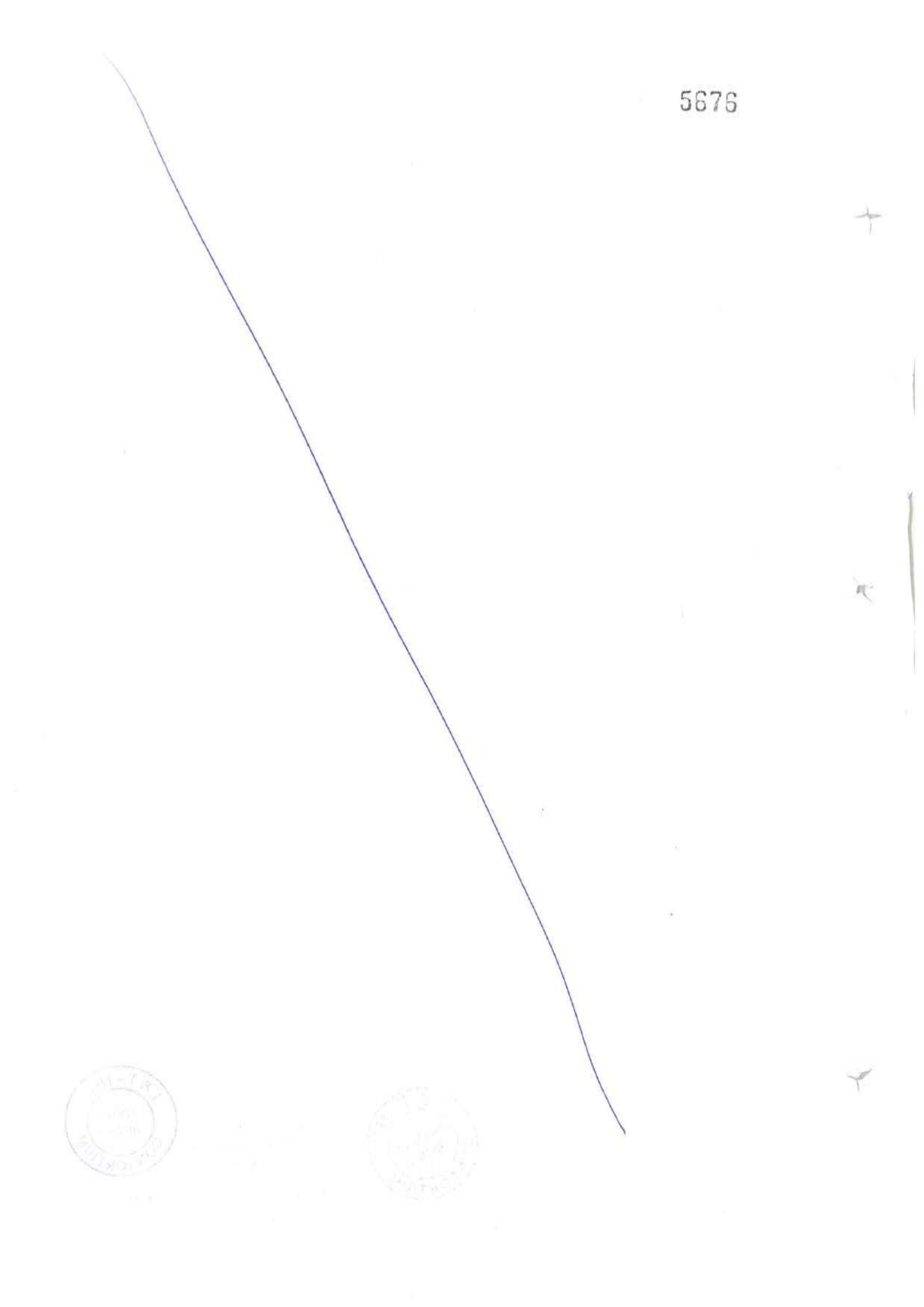
Documented Information for housekeeping is prepared at the start of the job by EHS coordinator.

Reference Procedures:

1. Procedure for Time Keeping & Industrial Relations
2. Procedure for EHS
3. Procedure for HR

7.1.5 Monitoring and measuring resources

7.1.5.1 General



This Project has established & maintains documented information for calibration of monitoring & measuring equipment to ensure that the equipment is capable of performing to required accuracy.

7.1.5.2 Measurement traceability

Any measurement of uncertainty noticed shall be assessed with respect to requirements and then decision shall be taken on their usage.

Where required and agreed to, calibration details pertaining to the inspection, measuring and test equipment shall be furnished to customer. The documented information for calibration addresses the following:

a) Calibration at prescribed intervals, traceable to local/ national/ international standards.
b) Identification to indicate calibration status.
c) Safeguard from adjustments, damages that will invalidate the calibration status and subsequent measurement results.
d) Maintenance of calibration records.

Reference Procedures:

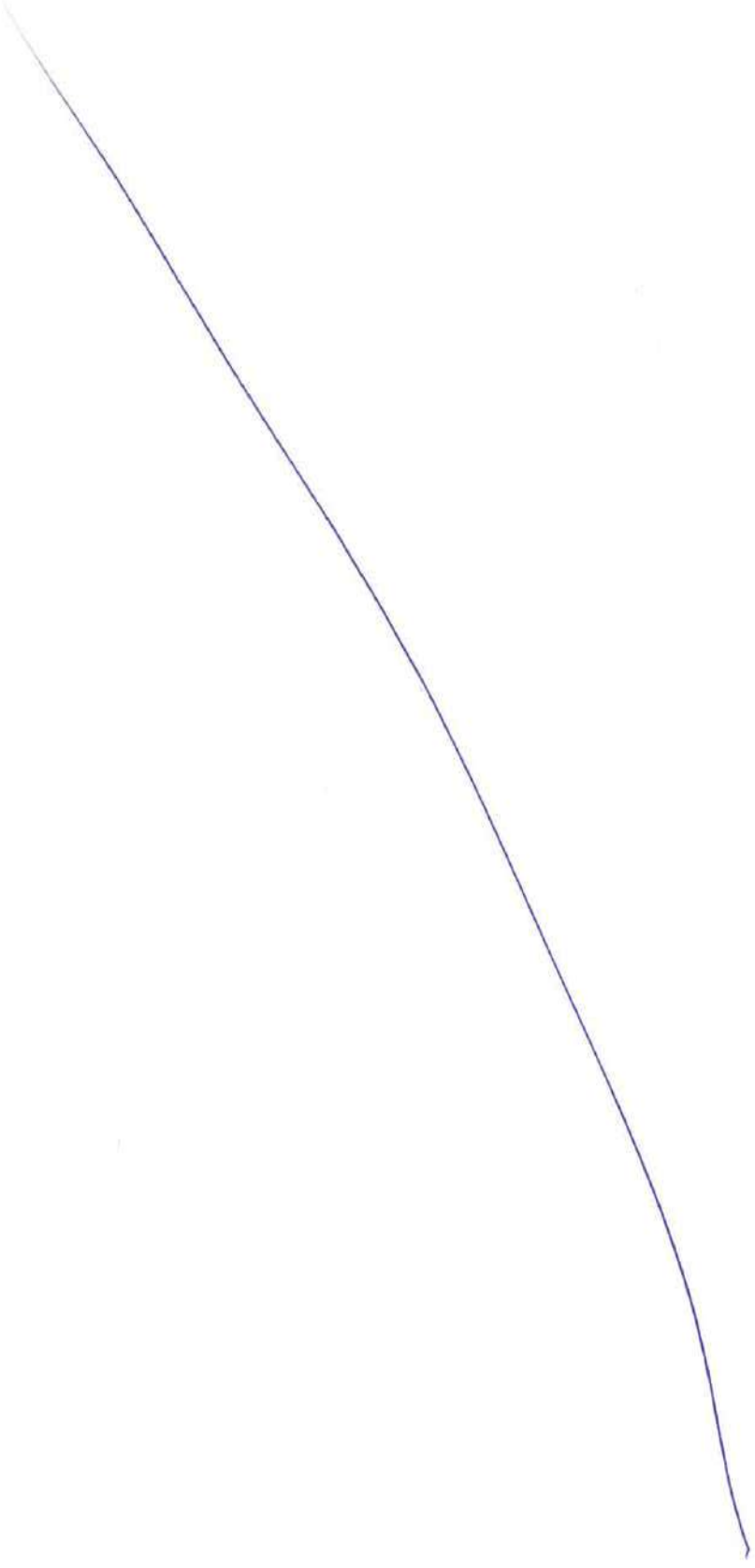
1. Procedure for calibration of Measuring & Test equipment – PQP WP 14

7.1.6 Organizational knowledge

This Project has determined to maintain the knowledge required for the operation of its processes and to achieve conformity of products and services.

Vendor data base, Collection of Codes and Standards, lesson learned & productivity norms from previous projects, data bank of operating rates, are few examples of organizational knowledge at project level. EIP portal contains & provides variety of information / knowledge required for projects. Facebook @ work is another mode used for sharing the organizational knowledge.

Additionally, this organizational knowledge is mutually shared between HQ (by BU operations/Cluster Heads) and Site Project In charge. Similarly, Project in charges and section heads at site level are exchanging knowledge gained through various interactions with customer & external providers and the same is shared to IC through informal discussions and review meetings.



7.2 Competence

This Project has determined to ensure the necessary competencies of persons executing project based on the education, training and experience.

Wherever applicable, Human resource Dept. is organizing trainings to acquire necessary competencies and evaluating their effectiveness. Procedure for Human Resources & Training **(PQP WP 06)** describes the identification of training needs and providing the same. The Procedure covers requirements for all

- Staff
- Workmen

Training is imparted during orientation and also during the progress of the job.

Effectiveness is evidenced through
- Process control records
- Internal audit

Action is taken based on the above.

Training records are maintained as indicated in the Procedure.

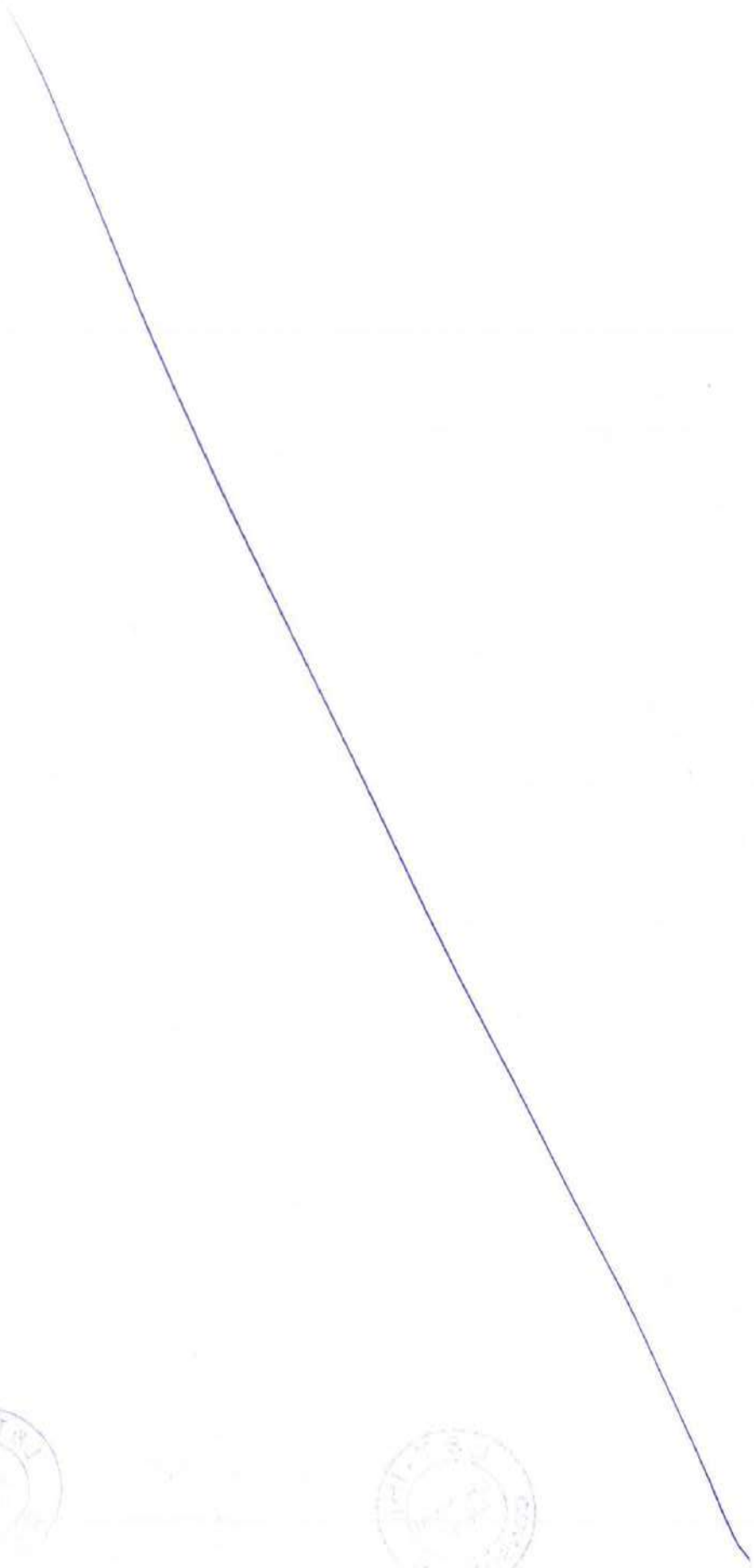
Reference Procedures:

1. Procedure Human Resources & training – PQP WP 06

7.3 Awareness

L&T-IHI Consortium has determined to create awareness to the entire spectrum of IC on quality policy, quality objectives their contribution to effective quality management system. MRM, review meetings, trainings and other occasions are few of the means at this Project to ensure the awareness. Also the effects or complications arising out of non-conformances of quality policy, objectives shall be made aware during in the above interactions.

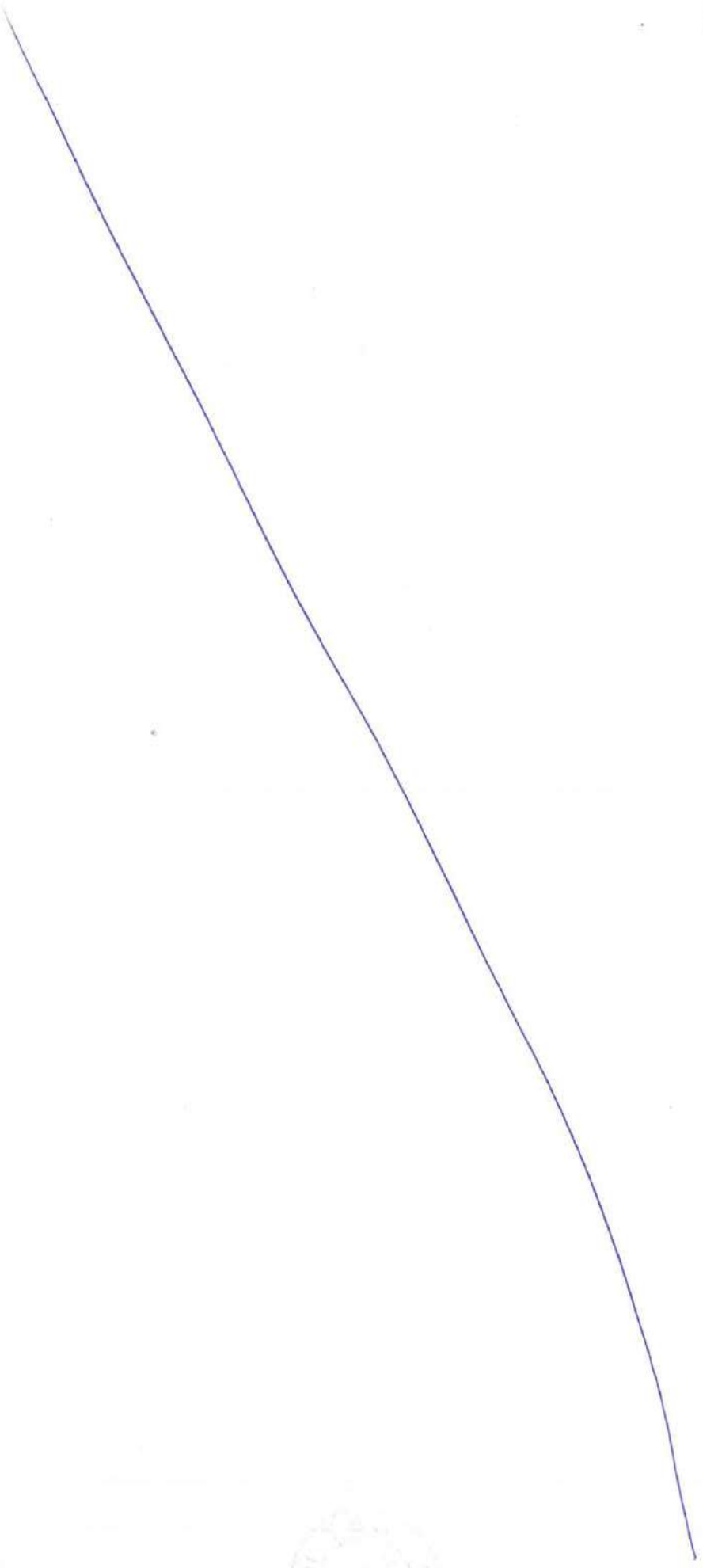
7.4 Communication



Quality Assurance Plan

The information required to be communicated to site & other external agencies and the mode of communication as shown in the following tables:

Subject of Communication	Mode of Communication	To Whom it is communicated	Who communicates
Vision, Mission & Values	Display Boards, Corporate magazines, QMS Documentation	All employees	Corporparate communication
Operating Policies	Management Guidelines & Circulars, QMS Documentation	All employées	IC Head
Corporate Objectives	Quality Policy, Budget, Guidelines	All employees	Corporate
Plans for new products / markets.	Circulars, Corporate magazines.	All employees	IC head, Corporate
Customer, Regulatory & Statutory requirements	Customer Interactions, Contract Documents, Government guidelines / gazettes, Circulars, File notes, Notice boards, Organization Policies.	Customer, concerned employees	Project In-charge, IC Accounts & Admin
Process Objectives	Quality Policy Deployment, Budget, Project Plans	All employees	Project In-charge
Process / Product Information	Customer meetings, Corporate Magazines	Customer, employees	Meeting coordinato Corporate communication
Problems	Management reviews, MIS, Structured Meeting at clusters, Audit	Attendees	Meeting coordinator, auditor
Progress	MPR, JCR, EIP	BU coordinators, Cluster heads, BUH, Accounts	Site Planning In-charge/accountan t



Change	Management Guidelines, Corrective & risk mitigations, Circulars, Periodic Reviews, Transfers, Document Changes	All employees	Corporate communication, HR,IC head, document originator
Results & Measurements	Management Information Systems, Audits	BUH, Clusters, BU coordinators	Site Planning In-charge, Site accountant, auditors
Work Procedures	Issued to all section In charge	Section Heads	Document controller
Methodology	Issued to all section In charge	Section Heads	Document controller

This communications are based on the necessity and requirements and also through scheduled meetings.

7.5 Documented information

7.5.1 General

For this Project, the Quality Management System documentation is detailed in **PROJECT QUALITY PLAN**, which includes the following:

a) Documented Information including quality policy and quality objectives.

b) Documented information required by the International standard and Organization for effective control of the processes.

c) Work Instructions / Distribution Lists.

d) Inspection & Test Plan with Formats

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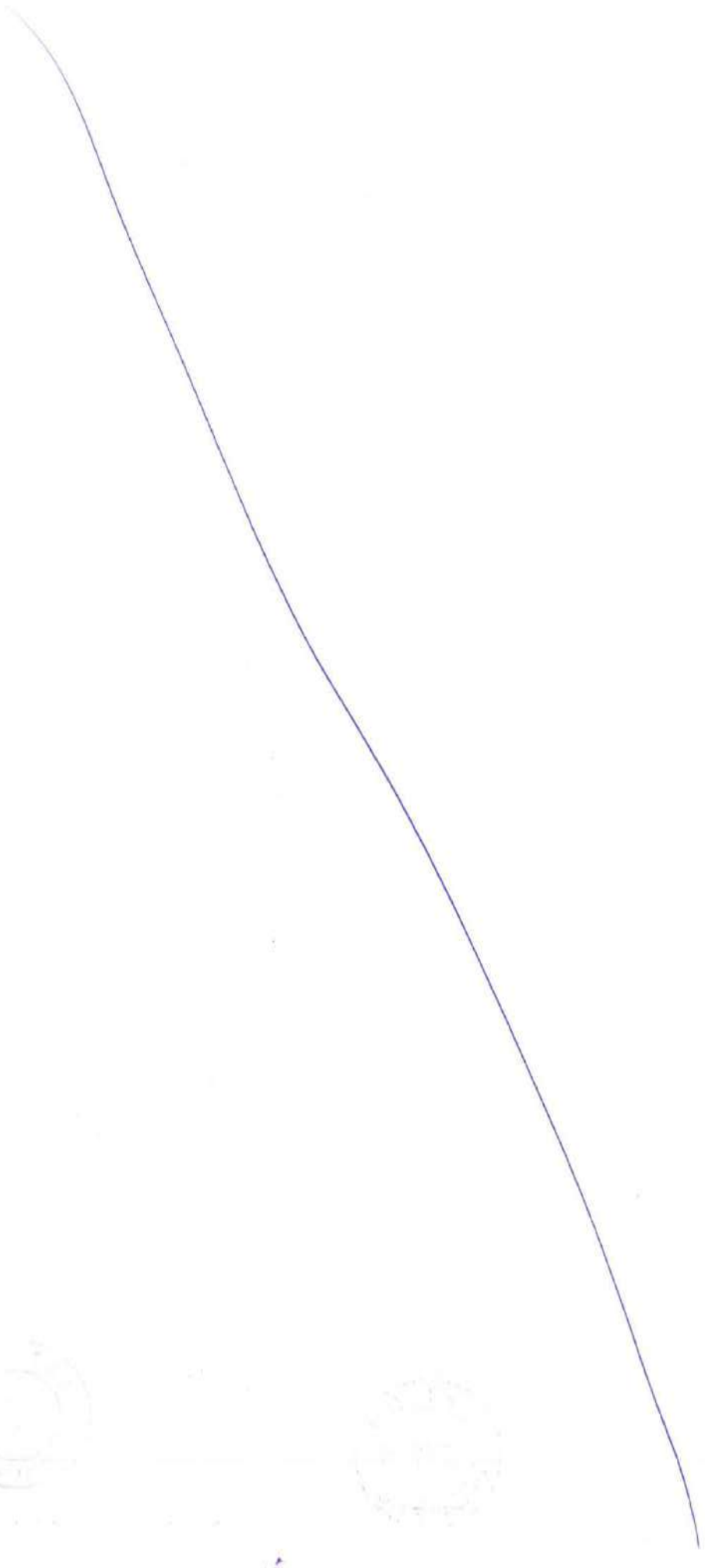
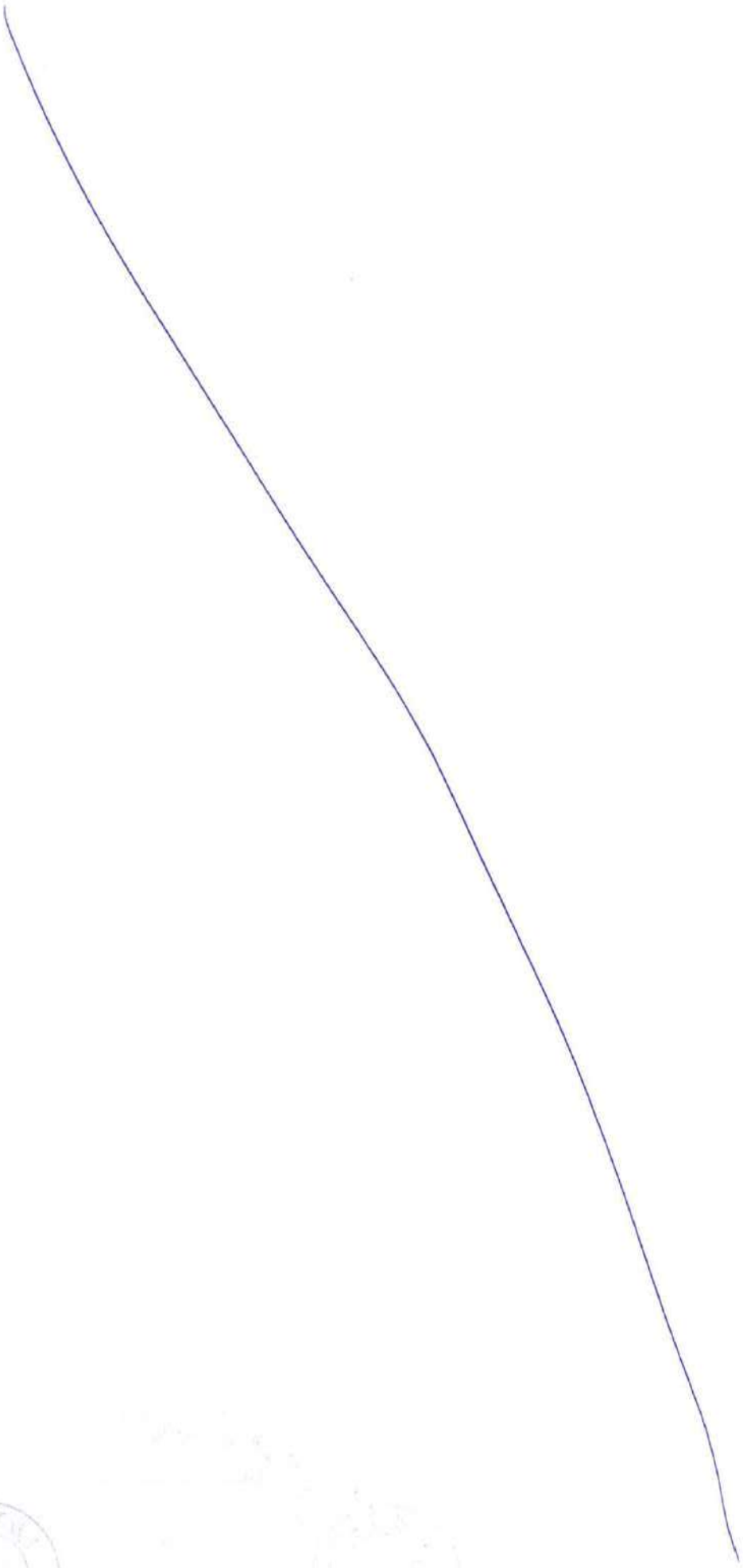
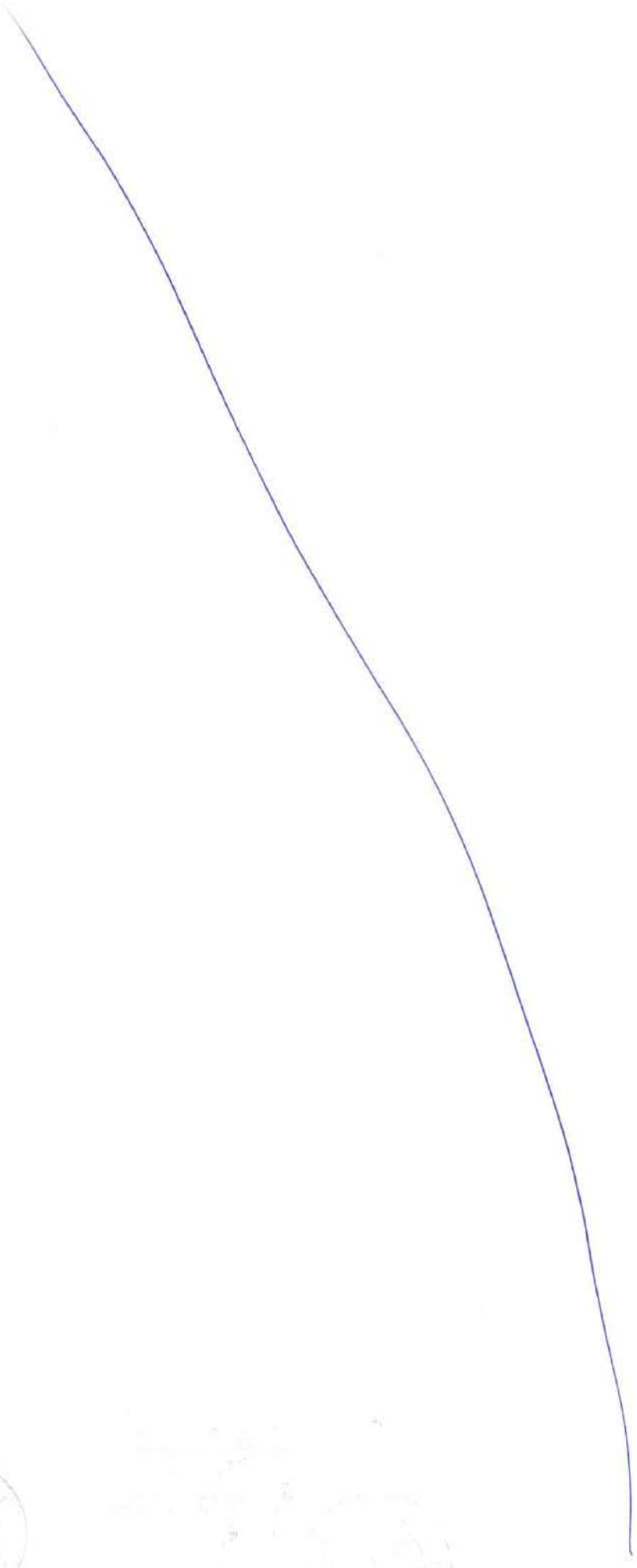


Detail list of Procedure is as below:

S.NO	PROCEDURE NO.	CLAUSE NO	PROCEDURE DESCRIPTION
1	PQP WP 01	5.1,6.2,10.3	QMS Planning
2	PQP WP 02	6.2,7.5.1,7.5.2,7.5.3,8.2.1,8.2.4,8.5.6	Control of Documented information
3	PQP WP 03	7.5.2,7.5.3,8.1,8.2.4	Control of Records
4	PQP WP 04	5.3	Organization Chart
5	PQP WP 05	5.1,6.3,7.1.1,8.2.4,8.5.6,9.1,9.3	MRM
6	PQP WP 06	7.1,7.2	Human Resource And Training
7	PQP WP 07	7.1,8.1,9.1	Project Planning And Monitoring
8	PQP WP 08	8.2.4	Contracts Management
9	PQP WP 09	8.1,9.1,	Mobilization Review And Monitoring of Project



10	PQP WP 10	8.4	Selection Of Vendor, Procurement
11	PQP WP 11	6.1,10.2,10.3	Actions to address risks & opportunities
12	PQP WP 12	8.5.2	Identification Traceability
13	PQP WP 13	8.5.4	Preservation, Handling And Storage
14	PQP WP 14	7.1.5	Calibration Of Measuring Test Equipment
15	PQP WP 15	5.1.2,7.1,8.2.1,10.2,10.3	Customer Feedback
16	PQP WP 16	9.2,10.3	Internal Audit
17	PQP WP 17	8.1,8.4,8.5,8.7,9.1,10.2	Inspection And Testing And Control of Non-Conforming Products
18	PQP WP 18	9.1,10.2,10.3	Corrective Action Procedure
19	PQP WP 19		Cancelled
20	PQP WP 20	9.1.3	Analysis Of Data



21	-	-	List of Identified ITP
22	-	-	List of Identified Method Statements
23	-	-	Formats

Department specific processes are covered by exclusive documented information as listed below and maintained by respective HODs as required:

Design – EDRC Quality Manual
Plant & Machinery - P&M Quality Manual
EHS _ EHS Quality Manual

7.5.2 Creating and updating

This Project has established and maintains procedure for creating and updating documented information which ensures appropriate identification, description, type of format, review & approval for suitability, adequacy etc.

Reference Procedures:

1. Procedure for Documented Information – PQP WP 02.
2. Procedure for control of records – PQP WP 03.

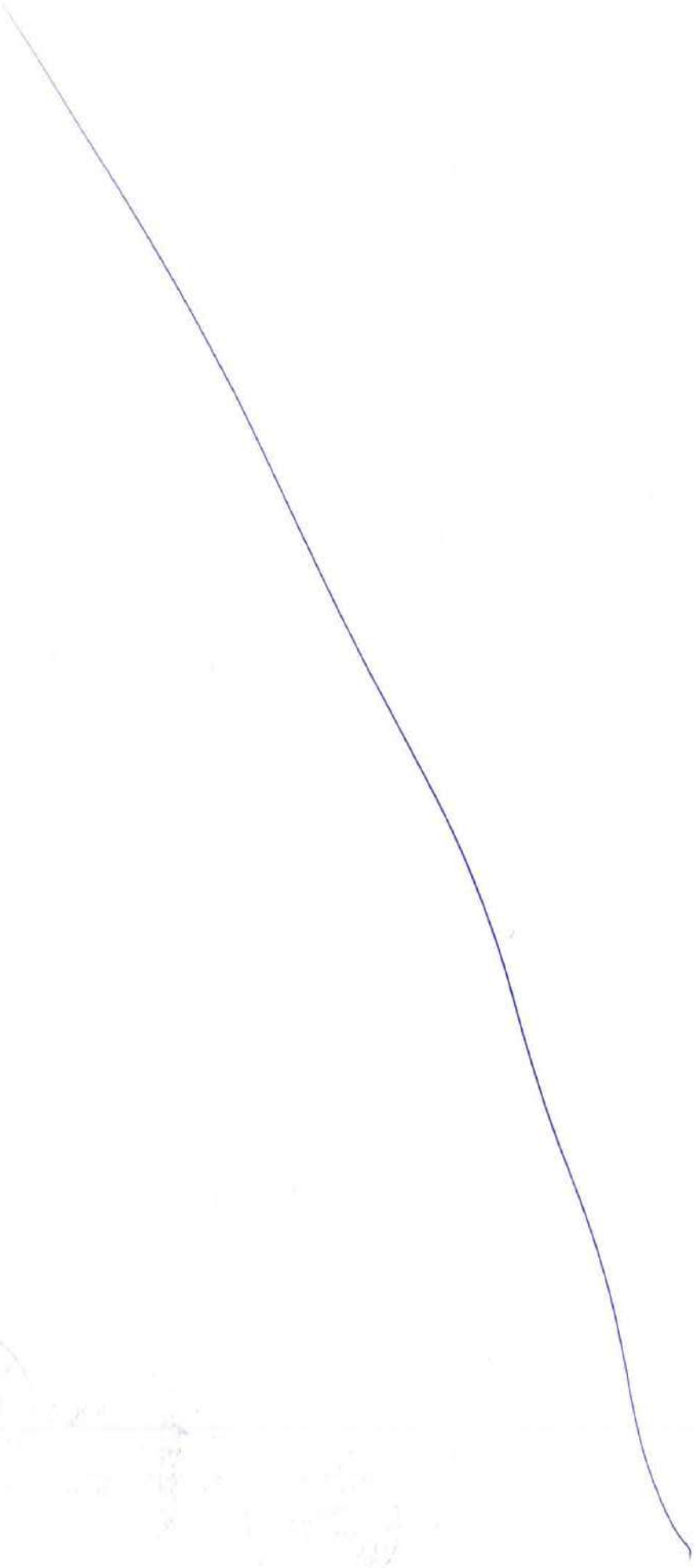
7.5.3 Control of Documented Information:

Documents

This Project has established and maintains procedure for Documented Information (PQP WP 02).It indicates types of documents and its method of control at project. This procedure also describes the responsibility to prepare, review, approve, issue & control.

Reference Procedures:

1. Procedure for Documented Information – PQP WP 02.



Records

THIS Project has established and maintains Procedure for control of records **(PQP WP 03)**, which describes the method of identification, collection, indexing, storage, and retention and assigns responsibility of maintaining the records. Records are stored in a manner that they are readily retrievable and prevented from damage and deterioration.

Wherever required by the contract, records are made available to the Customer or his representatives. The Procedure also spells out the location of records and the retention period of the same.

Reference Procedures:

1. Procedure for Documented Information – PQP WP 02.
2. Procedure for control of records – PQP WP 03.

8.0 OPERATION

8.1 Operation planning and control

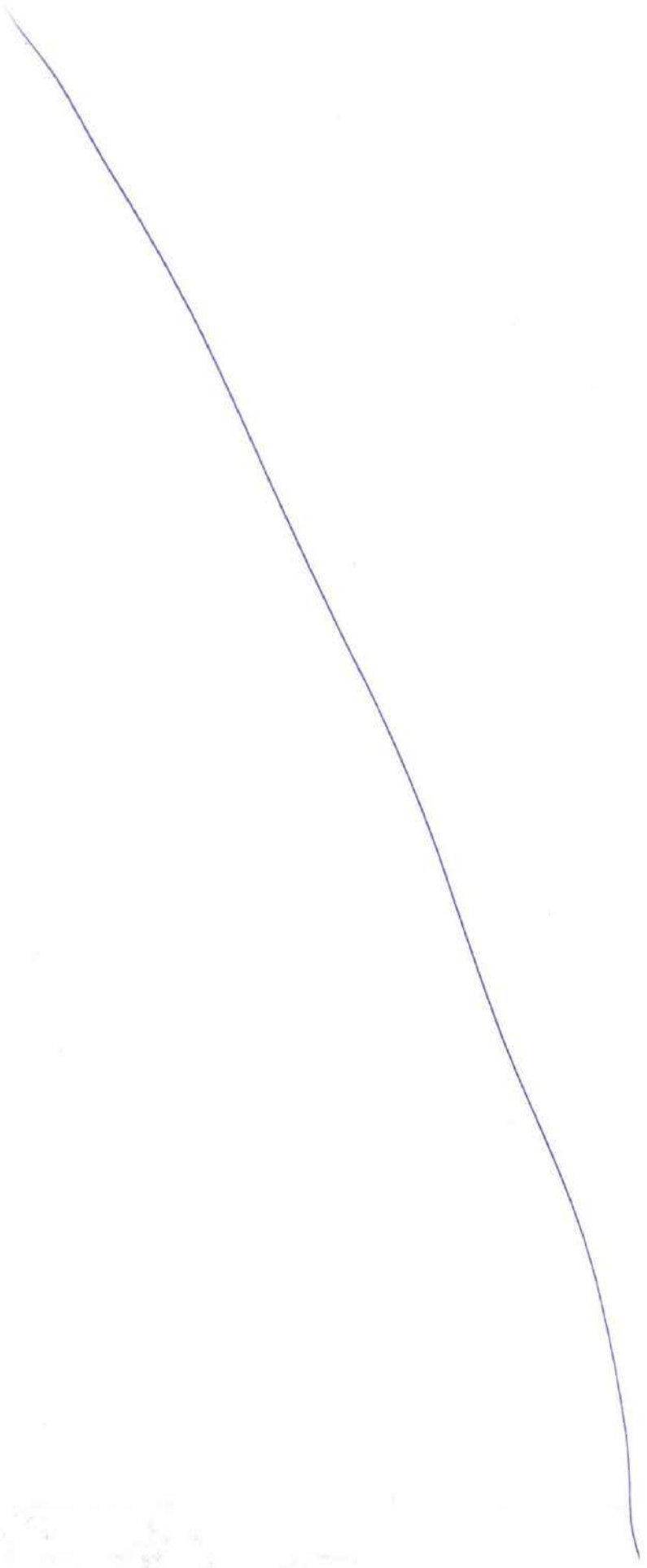
This Project has established the documented information for Project planning & monitoring, implementation and control of construction activities of project. This documented information describes various processes carried out to execute the project as per approved Plans & Methods as per contract.

It has established documented information for inspection & testing (ITPs) and control of non-conforming product, which covers planning and conducting Inspection, and testing of raw materials, process & product. The test results are verified to confirm that the product meets the acceptance criteria. List of identified ITP's and Method Statements are attached. (Refer Page no: 41)

It also established the documented information for control of records to demonstrate the requirements of product at various stages are met.

Reference Procedures:

1. Procedure for Project planning & monitoring –PQP WP 07
2. Procedure for Inspection & testing and control of Non-conforming products – PQP WP 17
3. Procedure for control of records –PQP WP 03



As the organization has established EIP for planning & control of projects, the respective reports related to costing, progress of work and financials are maintained in soft form in portal.

8.2 Requirements for products and services

8.2.1 Customer communication

Project in-charge represents the organization to the customer. He directly interacts with customers for the day to day needs. The interaction takes places on issues like Project execution, progress reports, revised plans, change in scope, and invoicing, statutory & regulatory requirements as per contracts, customer satisfaction.

He also interacts on the organizations capabilities, new areas of work, business promotion, and Product information.

Internal communication as stated in PQP Section 7.4 will be shared with customer on case to case basis.

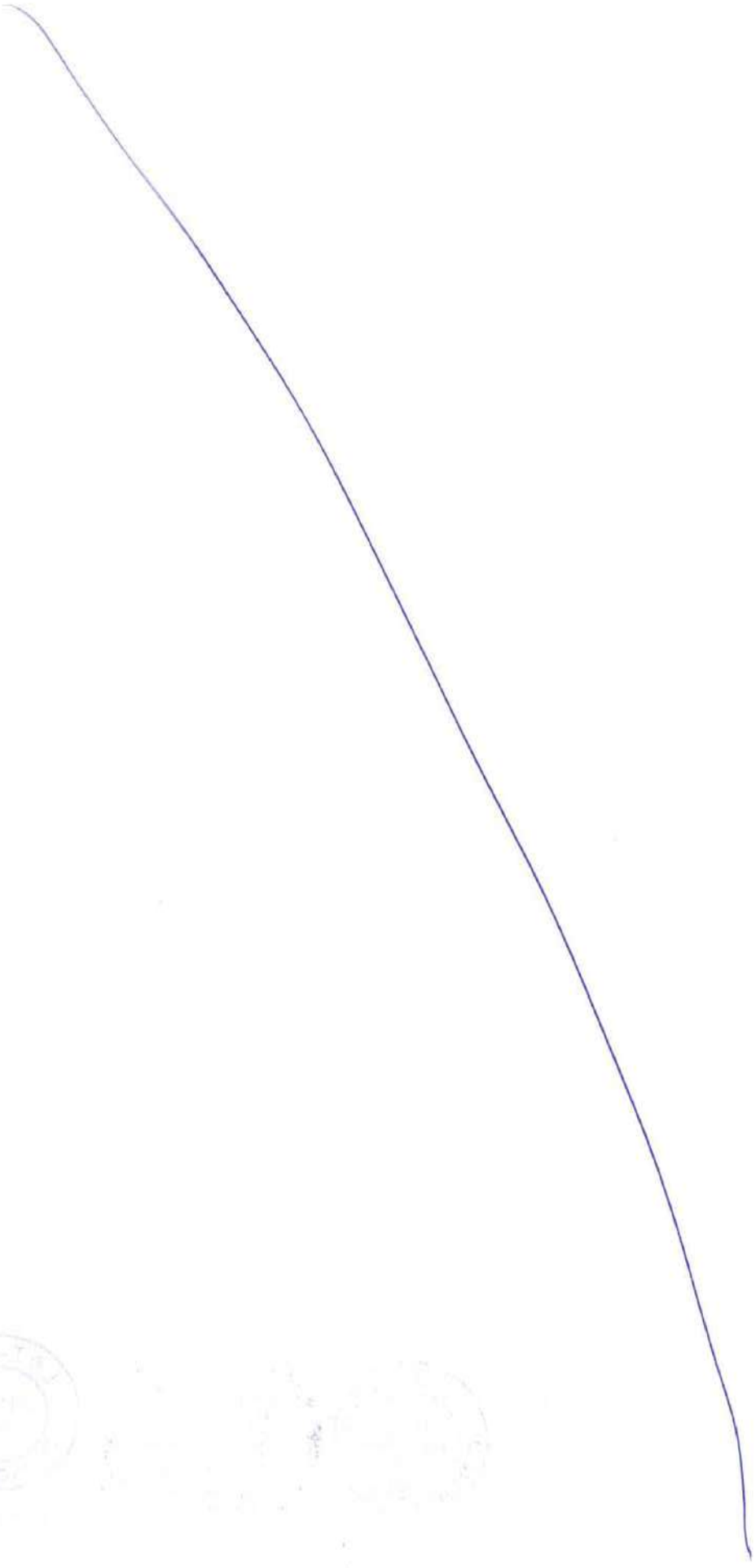
Reference Procedures:

1. Procedure for customer feedback – PQP WP 15
2. Procedure for Documented Information – PQP WP 02

8.2.2 Determining the requirements for products and services

The contract reviews are done to determine the customer requirements related to the product and services during tendering stage and also during the execution phase.

(Indicate here the list of submittals as agreed with customer contractually)



Sl No	Item	Description
1	Aggregate Processing Plant	Details of equipment capacity, Layout of processing and handling Equipment
2	Batching and mixing plant	Details of the Equipment, capacity, layout, flow diagram etc.,
3	Concrete Cooling Plant	Details of the Refrigeration and Ice plant, capacity, layout, flow diagram etc.,
4	Transportation of Concrete	Details of the equipment and methods of transporting from the mixing plant, type and capacity of transport vehicles etc.,

In addition to the above customers need and exceptions are also identified as described in the Procedure for Customer feedback – **PQP WP 15**

8.2.3 Review of the requirements for products and services

Project in-charge with his team members reviews the customer requirements and organization's ability to meet the same. Also the input of review for the particular project at time of tendering is taken into consideration at time of Kick-off meeting.

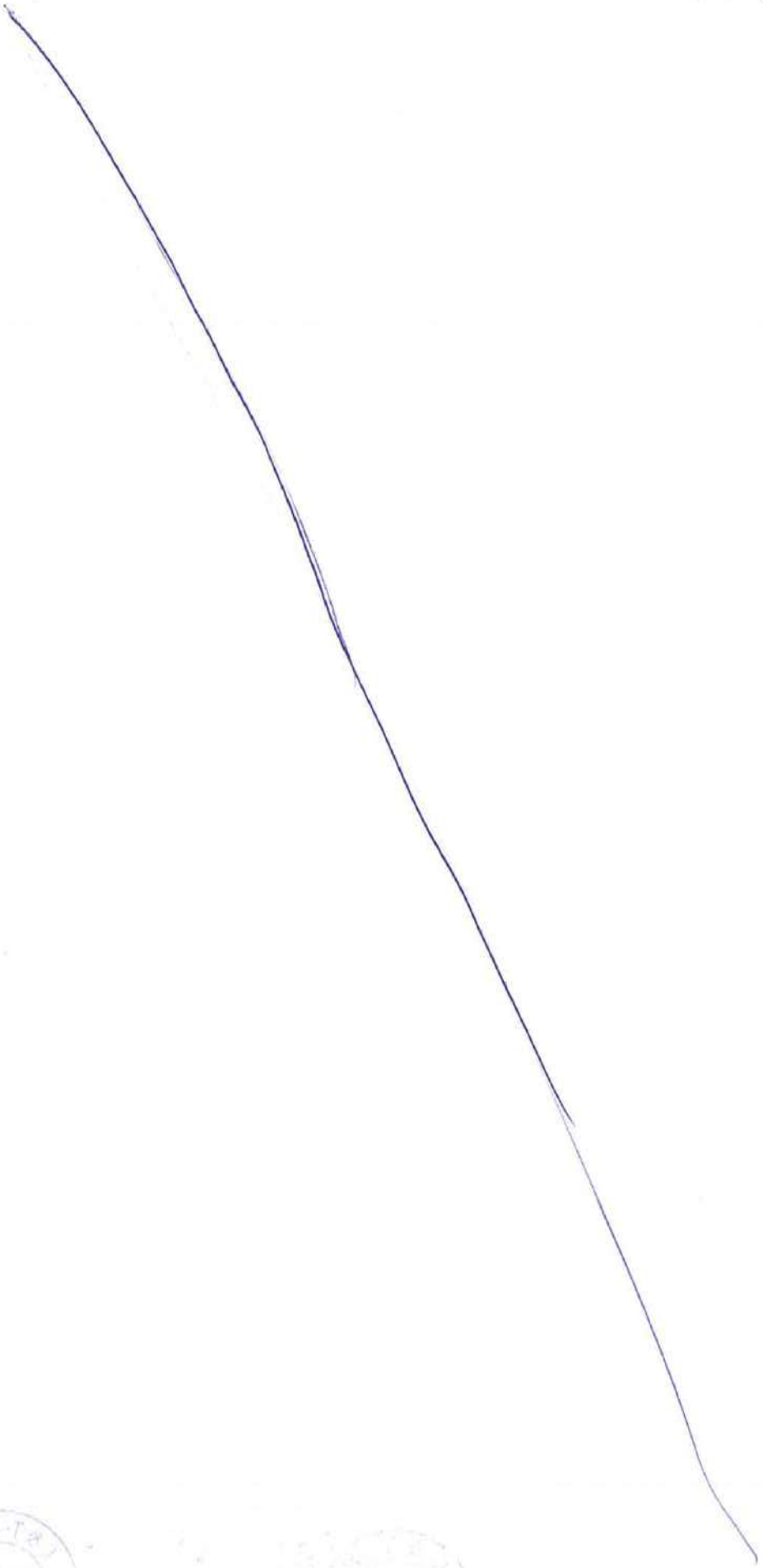
The review of project with customer is handled in meetings attended by customer.

8.2.4 Changes to requirements for the products and services

Changes to the requirements for the products and services that are raised internally and externally are reviewed for amendment.
Based on the amendments, relevant documents such as drawings, specification, Procedure, contract etc., are revised and cascaded through MRM under the heading of "changes in the external and internal issues that are relevant to the Quality management system"

Reference Procedures:

1. Procedure for Contracts Management – PQP WP 08.
2. Procedure for Documented Information – PQP WP 02.
3. Procedure for control of records – PQP WP 03.
4. Procedure for management review - PQP WP 05.



8.3 Design and development of products and services

L&T-IHI Consortium has established, implemented and maintains a design and development process that is appropriate to ensure the subsequent provision of products and services. This includes the following:

1. Design and development planning
2. Design and development inputs
3. Design and development controls
4. Design and development outputs
5. Design and development changes

Design & Construct Contracts (Select if applicable)

For this Project, Main Design is a part of the contract. And design specific detailed processed are addressed in EDRC Quality Manual.

Construction Contracts (Select if applicable)

The scope under this clause is limited to design of temporary works that facilitate construction of permanent works.

CMPC at HQ / this Project provides services for Design of construction of temporary facilities at Projects.

Wherever required the necessary design details are submitted to customer for information or Approval.

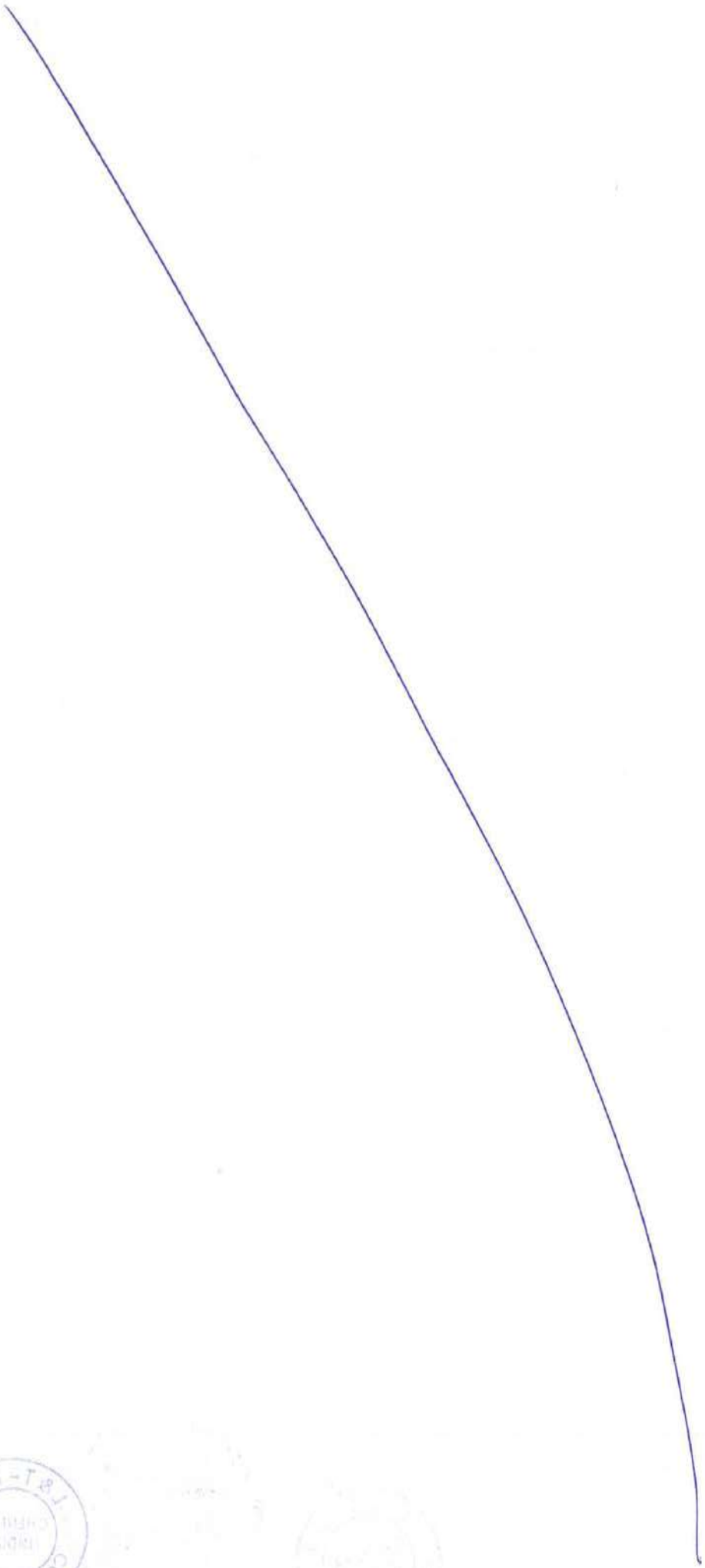
8.4 Control of externally provided processes, products and services

8.4.1 General

This Project has established and maintains documented information for selection of External provider's. This documented information describes criteria for selection, evaluation and revaluation of suppliers based on their ability to supply products in accordance with the product & organization's requirements. Documented information shall be maintained and updated in EIP.

Reference Procedures:

1. Procedure for selection of External Provider's & procurement PQP WP 10



2. Procedure for Inspection & testing and control of non-conforming products– PQP WP 17

8.4.2 Type and extent of control

This Project has established documented information for inspection & Testing, which describes how the materials are inspected at various stages including raw materials at receipt or at External provider premise based on product. Considering the type and extent of control on external provider & products/services, applicable QAPs are prepared, approved and implemented.

Reference Procedures:

1. Procedure for selection of External Provider's & procurement - PQP WP 10
2. Procedure for Inspection & testing and control of Non-conforming products– PQP WP 17

8.4.3 Information for external providers

This Project ensures the adequacy of requirement for external providers prior to their communication. Documented information is maintained to communicate the requirements for the processes, products and services to be provided. Purchase request, approvals, orders are processed through EIP and communicated to external providers.

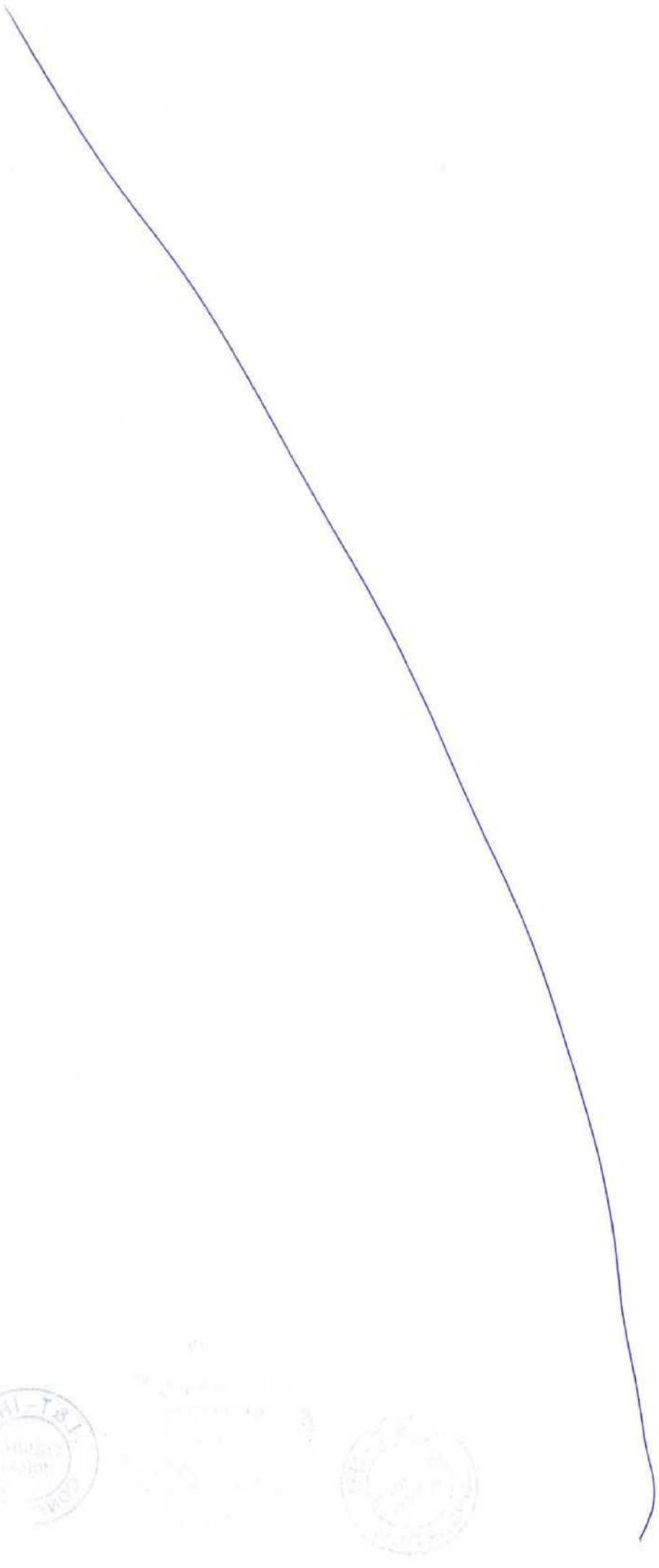
Reference Procedures:

1. Procedure for selection of External Provider's & procurement - PQP WP 10

8.5 Production and service provision

8.5.1 Control of production and service provision

Controlled conditions are established to implement production and service provision including:



a) Availability of QAPs, ITPs, work procedure, method statement, work instructions and guidelines that define characteristics of the product, services, activities to be performed and the results desired
b) Availability of suitable monitoring and measuring resources and their verifying mechanism
c) Use of suitable infrastructure and environment for the operation of processes
d) Ensuring competent persons with necessary qualifications
e) Validation & revalidations as applicable
f) Implementation of release delivery and post –delivery activities.

Reference Procedures:

1. Procedure for Inspection & testing and control of Non-conforming products – PQP WP 17

8.5.2 Identification and traceability

This Project has established and maintains documented information for control of material which describes how materials /products are identified from Receipt, storage, issue and handling

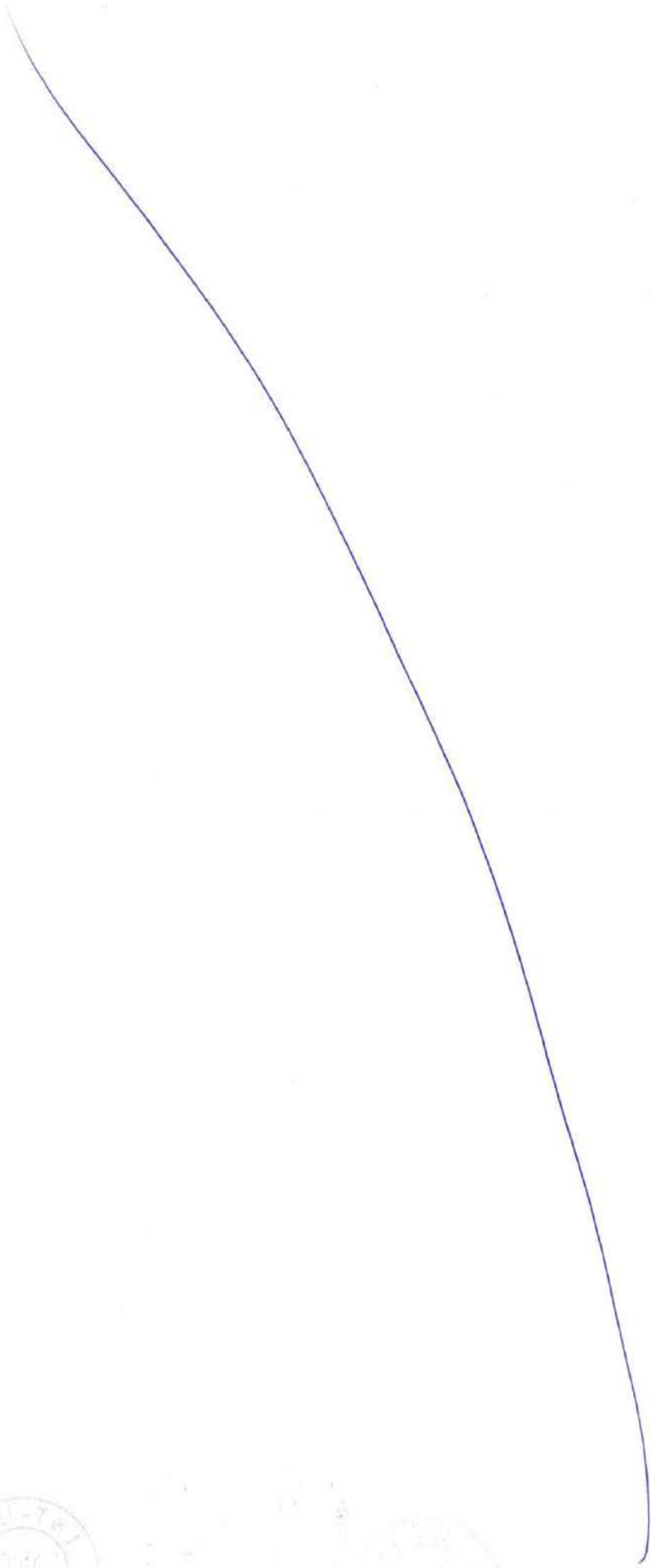
Reference Procedures:

1. Procedure for Identification Traceability – PQP WP 12

8.5.3 Property belonging to customers or external providers

Products and materials belonging to Customers shall be handled in the same manner as products and materials purchased by this Project with the mechanism as below:

- Stored / stacked as required by specification and shall be properly identified
- All TCs supplied by the Customer shall be preserved.
- If Customer supplied materials are received without test certificates, the same shall be informed to the customer and shall be tested prior to acceptance.
- If the supplied material fails to meet acceptable specification, the same shall be informed to Customer in writing with a request for further instruction.



- The received Material shall be retained and issued for use in accordance with L&T-IHI Consortium materials / stores documented information.
- Reconciliation statement for the above shall be taken up regularly.

The Customer shall be informed in writing in case of any loss, damage, incompleteness or other discrepancy regarding any products supplied.

The above shall also be maintained for properties belonging to external providers.

8.5.4 Preservation (Handling, Packing, Storage and Delivery)

Handling: All Materials including customer supplied, related to construction of project shall be handled as per requirements. Perishable items shall be handled in first in first out basis. Good housekeeping shall be maintained to ensure safety & easy handling as per EHS Documented Information.

Storage: Special storage requirements shall be identified and necessary arrangements shall be made for storage. Period verifications shall be carried out to ensure the materials are in good condition.

Preservation: The finished /completed product or parts of project shall be protected by suitable method to avoid damage till the project is handed over either partially or fully.

Delivery: Pre delivery and post-delivery checks shall be carried as required before handing over.

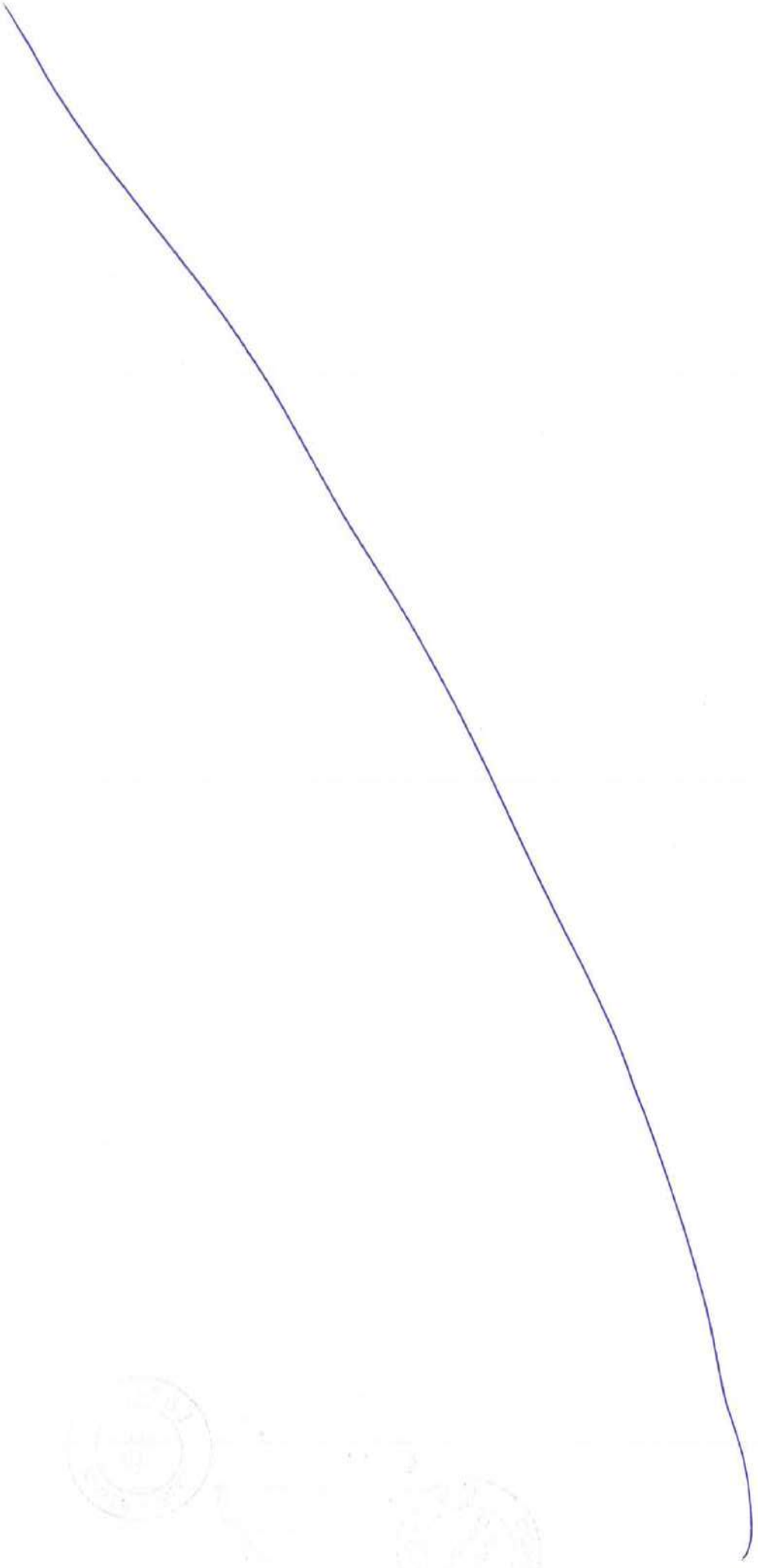
Reference Procedures:

1. Stores Procedure - for material control (receipt, storage, inspection & issue)
2. Procedure for Inspection& Test and control of non-conforming products– PQP WP17

8.5.5 Post-delivery activities

Post–delivery activity associated shall be performed determining to the extent of requirement considering,

a) Statutory and regulatory requirements
b) Potential undesired consequences
c) Nature, use and intended life



d) Customer requirement and feedback

In this this Project, resources are demobilized after contractual completion, except a limited crew required to take care of post –delivery activities (as applicable). When there are no such specific requirements as per contract, activities related to defect liability are handled at Head Quarters, when customer is communicating any such issues)

8.5.6 Control of changes

Changes in specification, quantity, and cost/price pertaining to contract shall be finalized with the customer for necessary amendments. Based on the amendments, relevant documents such as drawings, specification, contract etc., are revised and distributed to concern by the designated document controller. Further changes required in production and service provisions are reviewed during management review meetings and accordingly work methods, Procedures; QAPs etc., are revised and controlled.

Reference Procedures:

1. Procedure for Management Review - PQP WP 05
2. Procedure for Documented Information - PQP WP 02

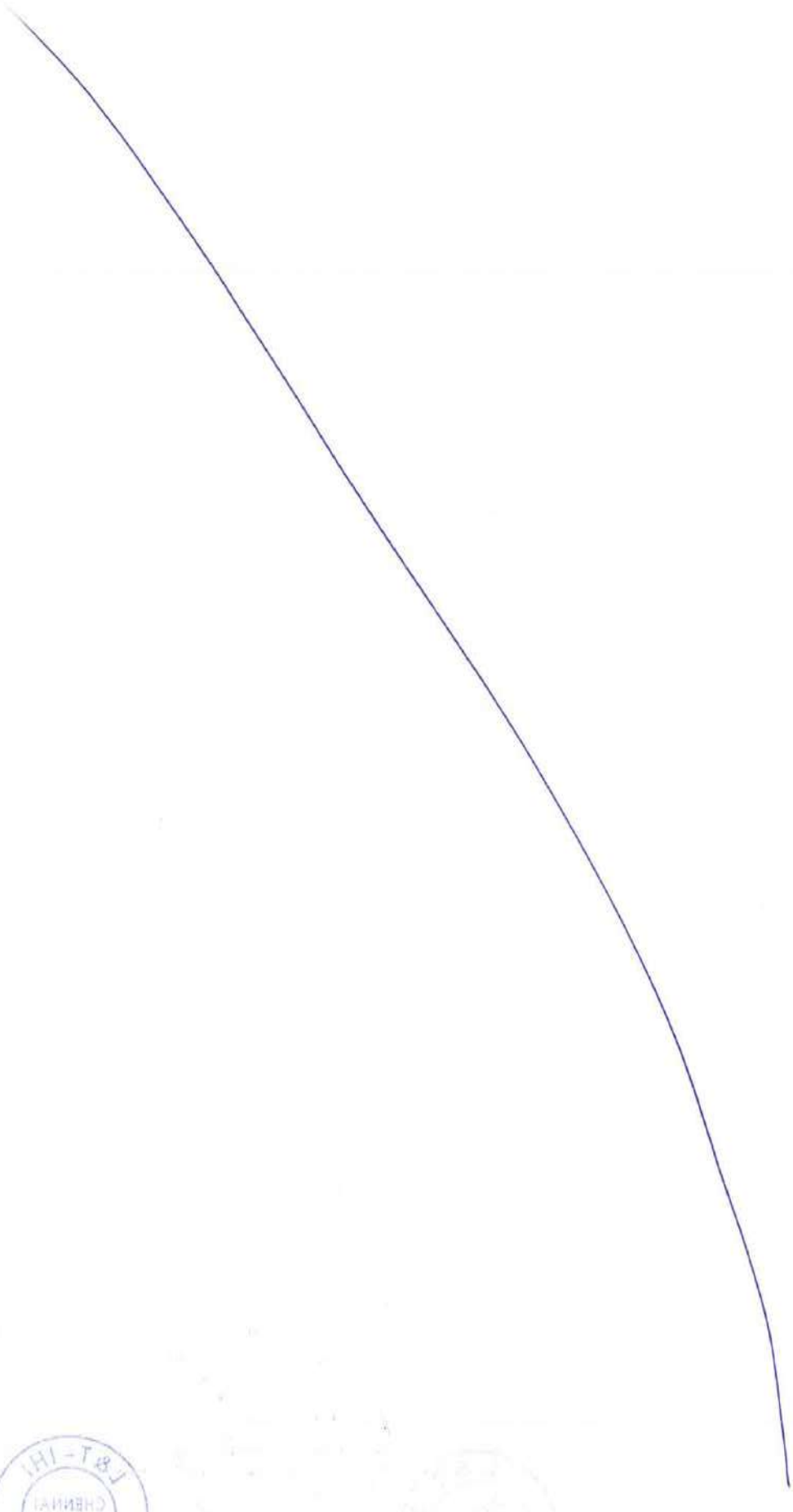
8.6 Release of products and services

This Project has established and maintains Procedure for inspection and testing (PQP WP 17) as per QAP/ITP .These QAP, ITPs describes the product requirements including acceptance criteria and format of records and authority to release the products or services. Documented information shall be maintained.

8.7 Control of nonconforming outputs

This Project has established and maintains Procedure for Inspection and Testing and control of non-conforming outputs PQP WP 17 to ensure that non – conforming products are prevented from unintended use. The documented information also defines identification, documentation, evaluation and disposition of non – conforming outputs.

Review & disposition of non – conforming outputs:



The documented information defines personnel responsible for review and those authorized for taking decision for disposition. Where required by contract, the proposed use or repair of product, which does not conform to specified requirements are referred to the customer for their approval.

Reference Procedures:

1. Procedure for Inspection &Testing And control of nonconforming products-PQP WP 17

9.0 PERFORMANCE EVALUATION

9.1 Monitoring, measurement, analysis and evaluation

9.1.1 General

This Project has determined established various documented information for measurement, analysis and evaluation of activities needed to ensure conformity & improvement.

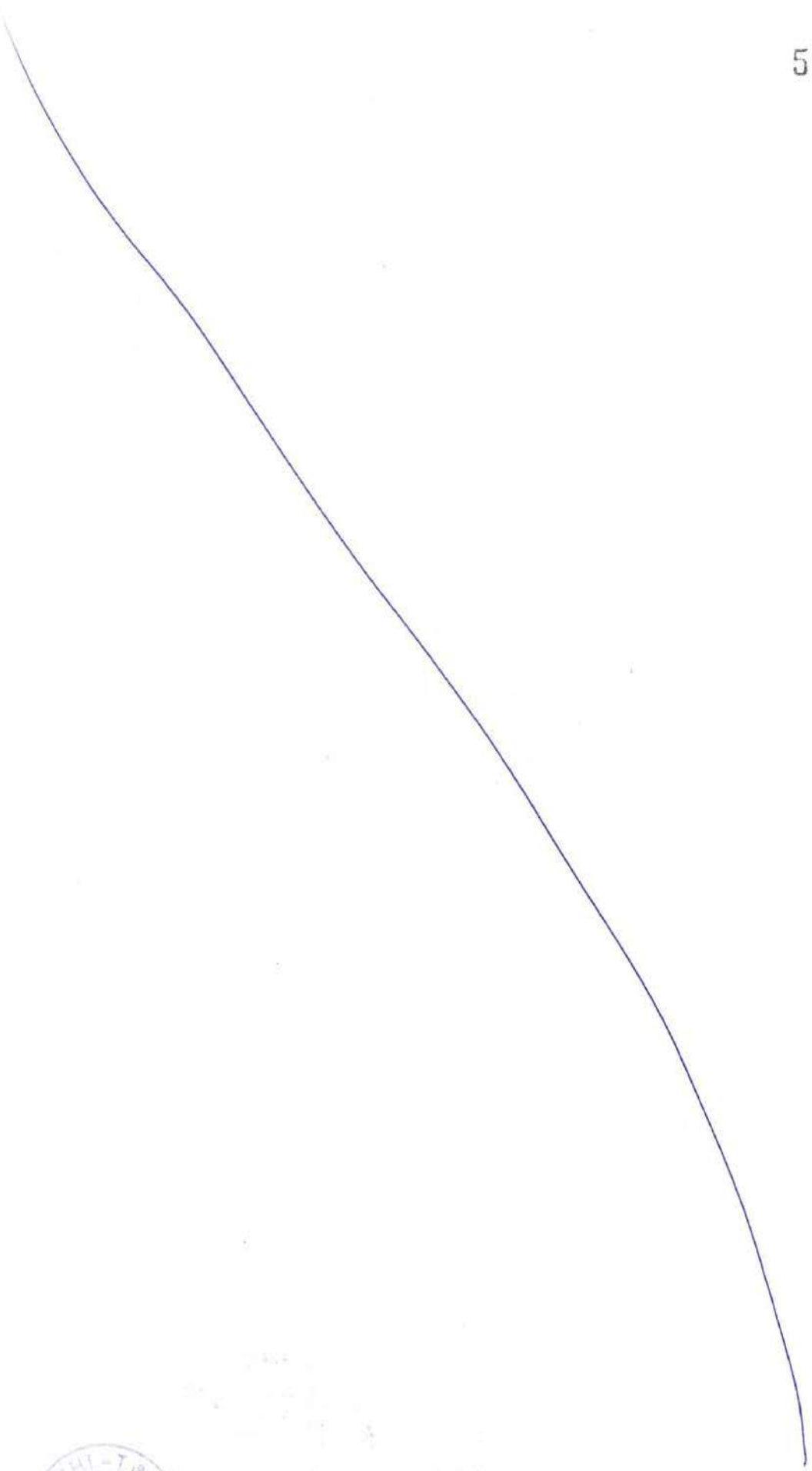
Following documented information describes how planning, implementation and measurements are carried out and also the methodology and tools used to demonstrate conformity of the product.

Reference Procedures:

1. Procedure for internal quality audit - PQP WP 16
2. Procedure for inspection & testing and Control of non-conforming product – PQP WP 17
3. Procedure for corrective action - PQP WP 18
4. Procedure for Management Review – PQP WP 05
5. Procedure for Project planning & monitoring – PQP WP 07

9.1.2 Customer satisfaction

This Project has established and maintains Procedure for 'Customer Feedback' – **PQP WP 15** which describes method of determining customer needs & expectations through customer satisfaction feedback questionnaire, other appreciations and complaints.



Customer feedbacks are analyzed for determining the needs & expectations. These are converted in to requirements through various documented information and objectives to implement the same for enhancing the customer satisfaction.

9.1.3 Analysis and evaluation

This Project has established and maintains documented information for verifying the requirements of product are met as per contract. This documented information describes the characteristics of the products to be measured and monitored to confirm the specified requirements at appropriate stages of product realization processes. The documented information also refers to quality plan and associated quality records that need to be maintained for objective evidence.

Reference Procedures:

1. Procedure for Inspection and Testing and control of non-conforming products - PQP WP 17
2. Procedure for Internal Quality Audit - PQP WP 16
3. Analysis of Data - PQP WP 20

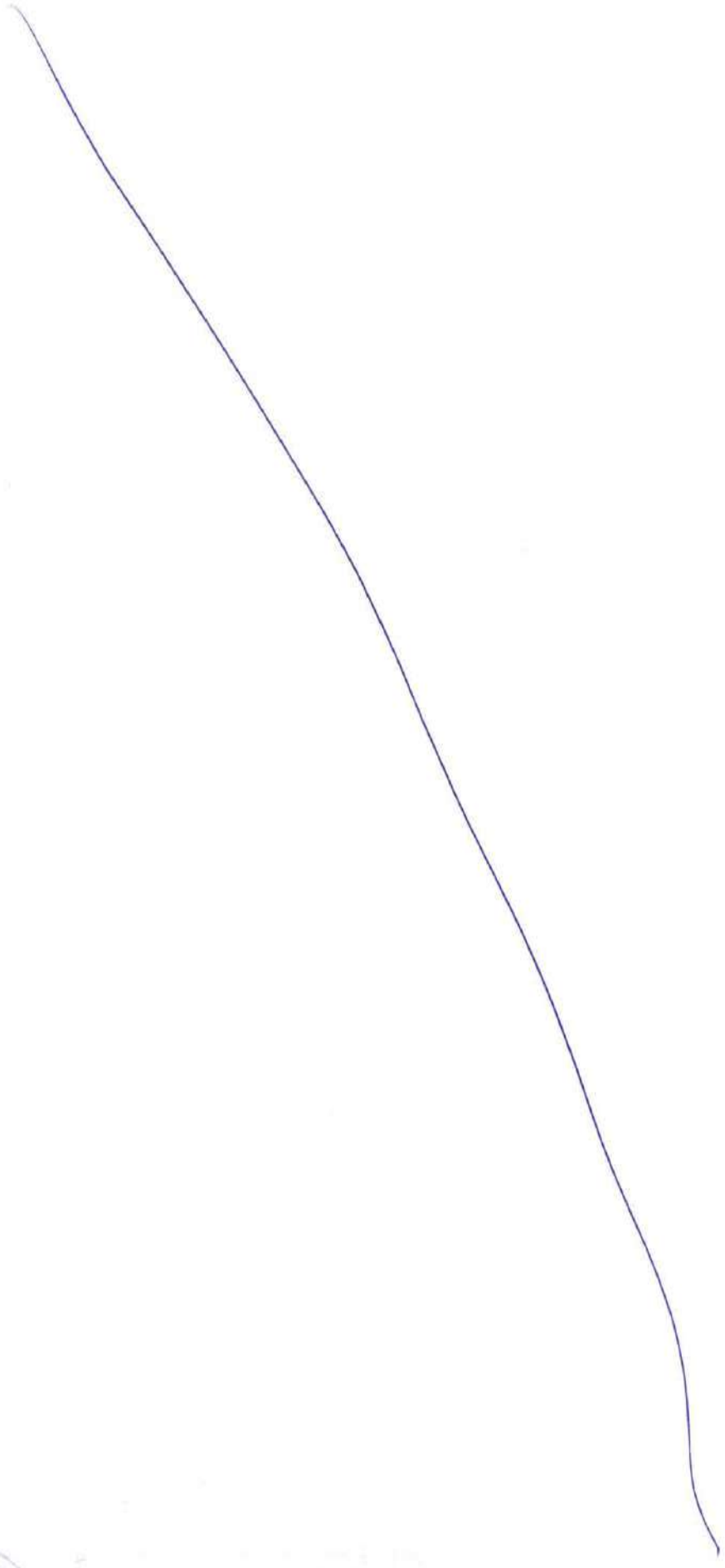
This Project has established and maintains the documented information to collect and analyze appropriate data to confirm suitability and effectiveness of QMS and to evaluate for continuous improvement.

Analysis of data relating to:

- Customer satisfaction
- Conformity to product requirements

9.2 Internal audit

This Project has established and maintains documented information for Internal Quality Audit PQP WP 16. This documented information describes how internal audits are planned and conducted to check the level of implementation and measure the effectiveness of QMS.



Audits are scheduled based on status, importance and criticality. The Auditors are trained to perform unbiased audits.

The results of audit are recorded and brought to the attention of top management by designated staff identified by Project In-charge through MRM for their timely corrective action. Follow up Audits are carried out if recommended to verify and record the implementation of the corrective action and its effectiveness.

Non-Conformities are discussed during Management Review Meeting for review and direction.

9.3 Management review

9.3.1 General

Management Review Meetings are conducted to review the Quality Management System at least once in three months to ensure its continuing suitability, adequacy and effectiveness including Quality Policy and objectives. Takes necessary action based on the target set. The meeting is attended by all dept. in charges & chaired by Project In-charge. These meetings are coordinated by designated staff identified by Project In-charge.

9.3.2 Management review inputs

The Management review includes of all applicable requirements of the QMS, related performance trends and opportunities for improvement follow up actions from earlier management reviews.

9.3.3 Management review outputs

The management review outputs include progress on Quality objectives, any related actions required for improvement of the QMS, analysis of CA etc.,

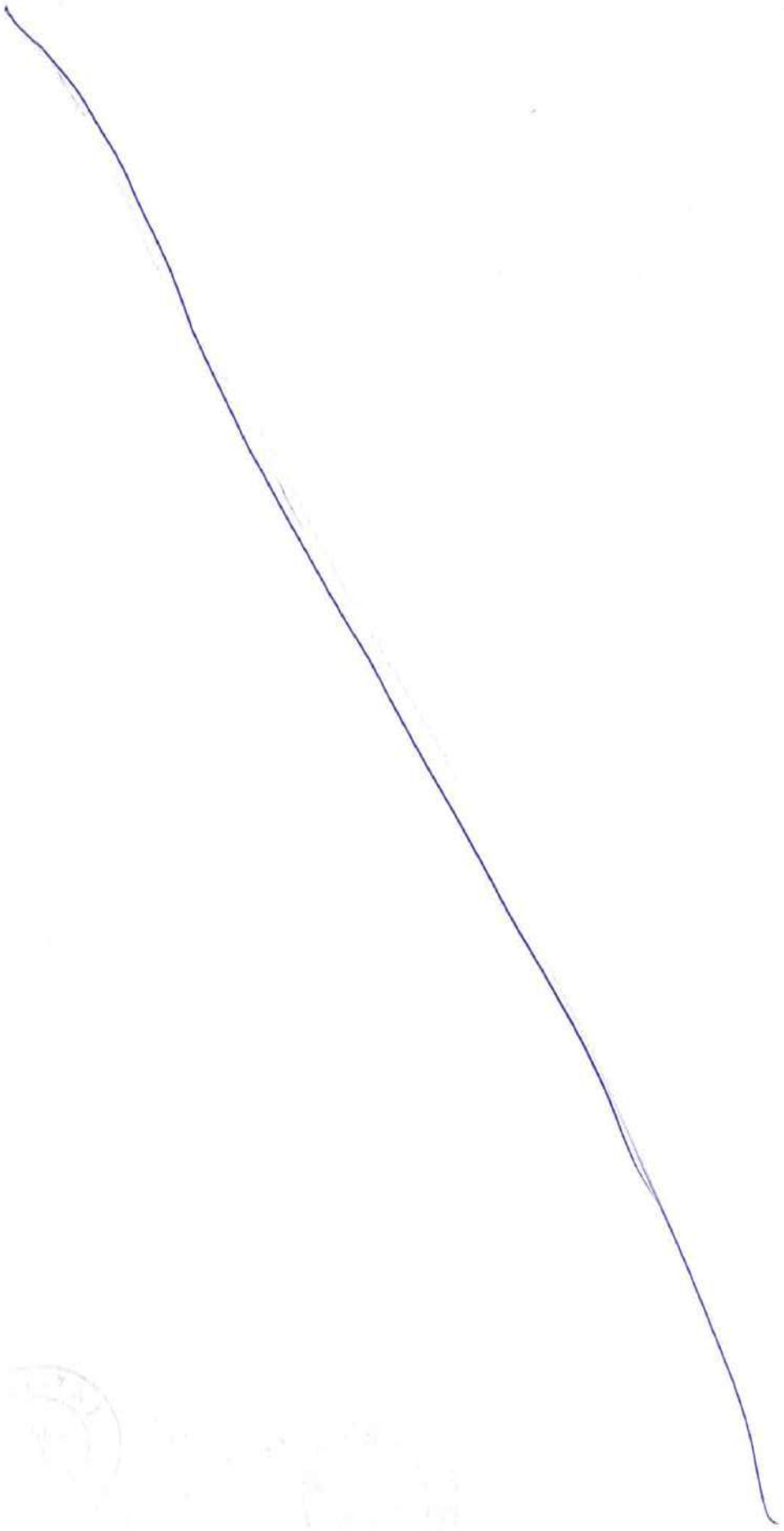
The QMS coordinator maintains the records of such meetings.

Reference Procedures

1. Procedure for Management Review - PQP WP 05

10 IMPROVEMENT

10.1 General



The project in-charge monitors & measures the processes of the quality Management system to achieve the planned results of the product as per contract. This is carried out by clearly preparing the Work methods, ITPs with details of stages of monitoring, measuring, sampling, acceptance criteria, reference documents and records to maintain and personnel responsible for the same.

10.2 Nonconformity and corrective action

This Project has established and maintains Procedure for corrective actions **(PQP WP 18)** Corrective actions are taken to prevent the recurrence of non-conformities. The actions taken are based on the magnitude of the problem and are commensurate with the risk involved to the customer. The changes arising out of such actions are maintained as documented information.

Corrective actions are triggered by customer complaints or non – conformities related to product, process and system. Identification of cause of problem & corrective actions to eliminate the problem is carried out as necessary.

Identification of problems and then determine the steps for problem solving. Action is then initiated to resolve the problem and apply control measures. Relevant information on action taken is captured in management review.

Reference Procedures:

1. Procedure for corrective actions - PQP WP 18
2. Procedure for customer feedback - PQP WP 15

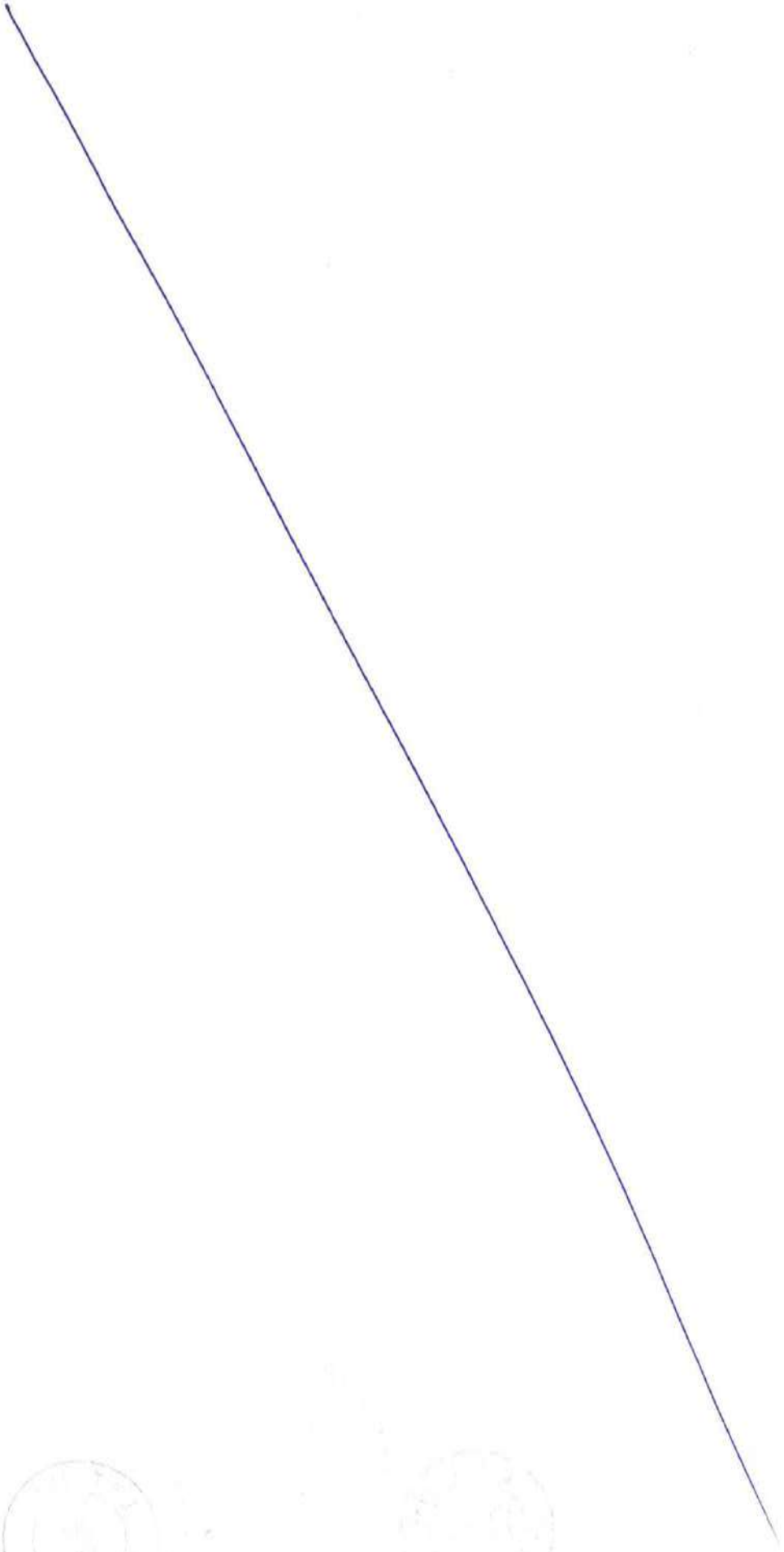
10.3 Continual improvement

Continual improvement can be achieved by making use of the results of implemented QMS.

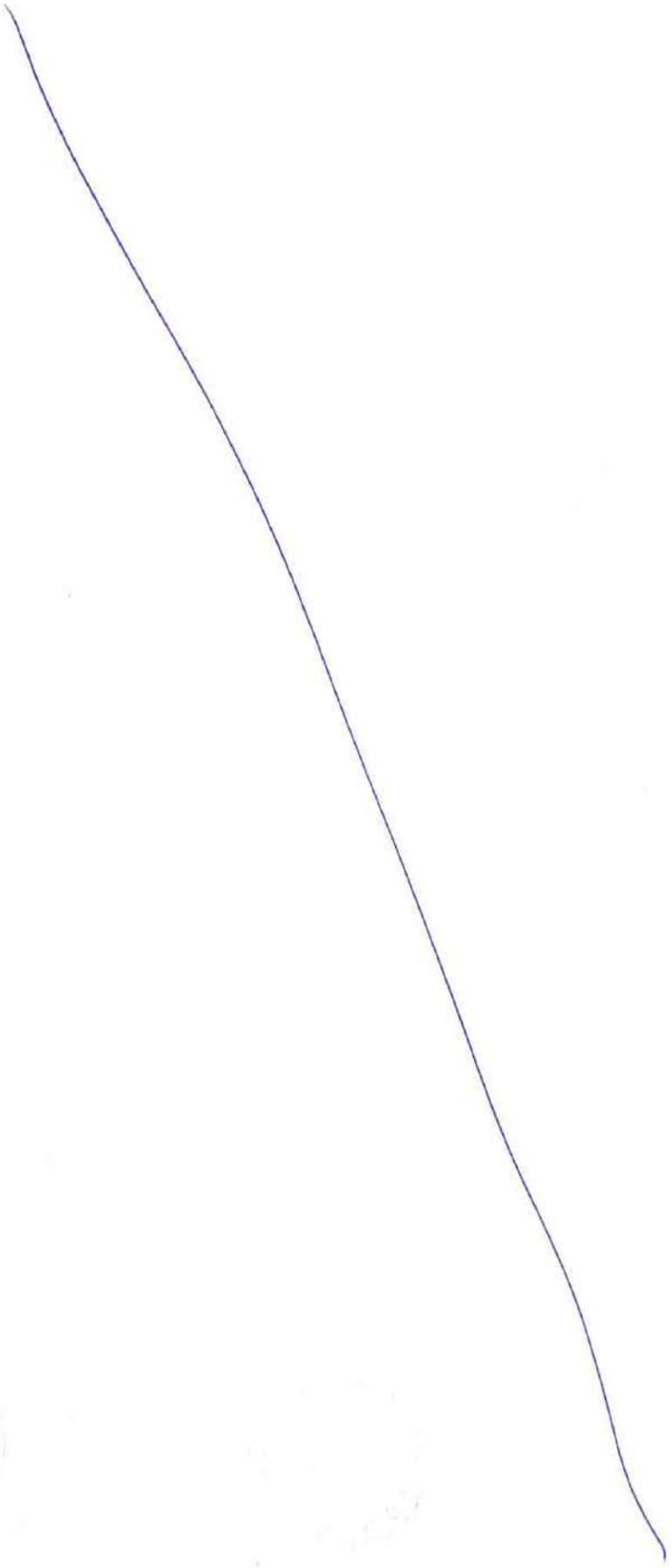
Reference Procedures:

1. Procedure for Planning of QMS & Quality Policy and objectives- PQP WP 01
2. Procedure for Customer Feedback - PQP WP 15
3. Procedure for Corrective Actions - PQP WP 18
4. Procedure for Internal audit - PQP WP 16

All the procedures referred in the above plan along with the annexures are attached as per the below index.



WORK PROCEDURES



Quality Assurance Plan

Reference ISO Clauses: 5.1, 6.2, 10.3

1. TITLE	:	**Procedure for setting Quality Objectives and planning to achieve them**
2. PURPOSE	:	To establish Quality management system planning (Project) including business objectives to meet customer and organization's goals.
3. SCOPE	:	Quality Management system (Project Quality Plan)
4. REFERENCE	:	ISO 9001-2015 QMS Standard Contract Procedure for Document control Procedure for Record control Procedure for Risk Management
5. RESPONSIBILITY	:	PRIMARY: Project in-charge SECONDARY: QMS Co-coordinator (site)

6. PROCEDURE:

6.1 Study the contract, ISO 9001-2015 QMS requirements.

6.2 Convert the Project execution strategy into initiatives for the site team and establish Quality Objectives based on Quality policy, project requirements for each function or process (Planning, Execution, Purchase, Quality, Safety, Stores etc). This comprises requirements of Quality, Safety &Timely delivery. During formulating quality objectives, relevant requirements of interested parties shall be taken into consideration.

6.3 Set desired / target values based on the following:

- Quality Policy
- Contractual commitments;
- Relevant to conformity of products
- Internal & external Issues
- Needs & expectations of interested parties

6.4 Review and Approve objectives.

6.5 Identify resources and assign responsibility.

6.6 Fix targets for completion & evaluation modality.

6.7 Draw action plan to achieve the quality objectives.

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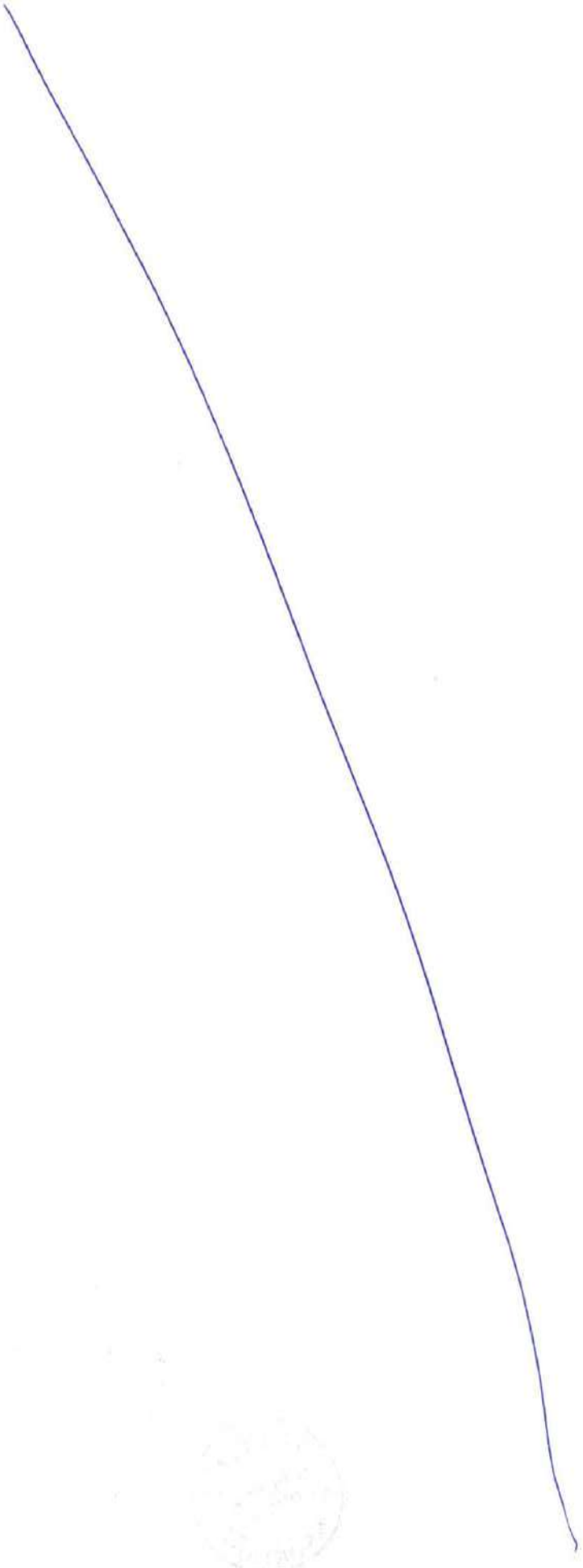


6.8 Monitor for implementation of Quality objectives and update objectives as and when required.

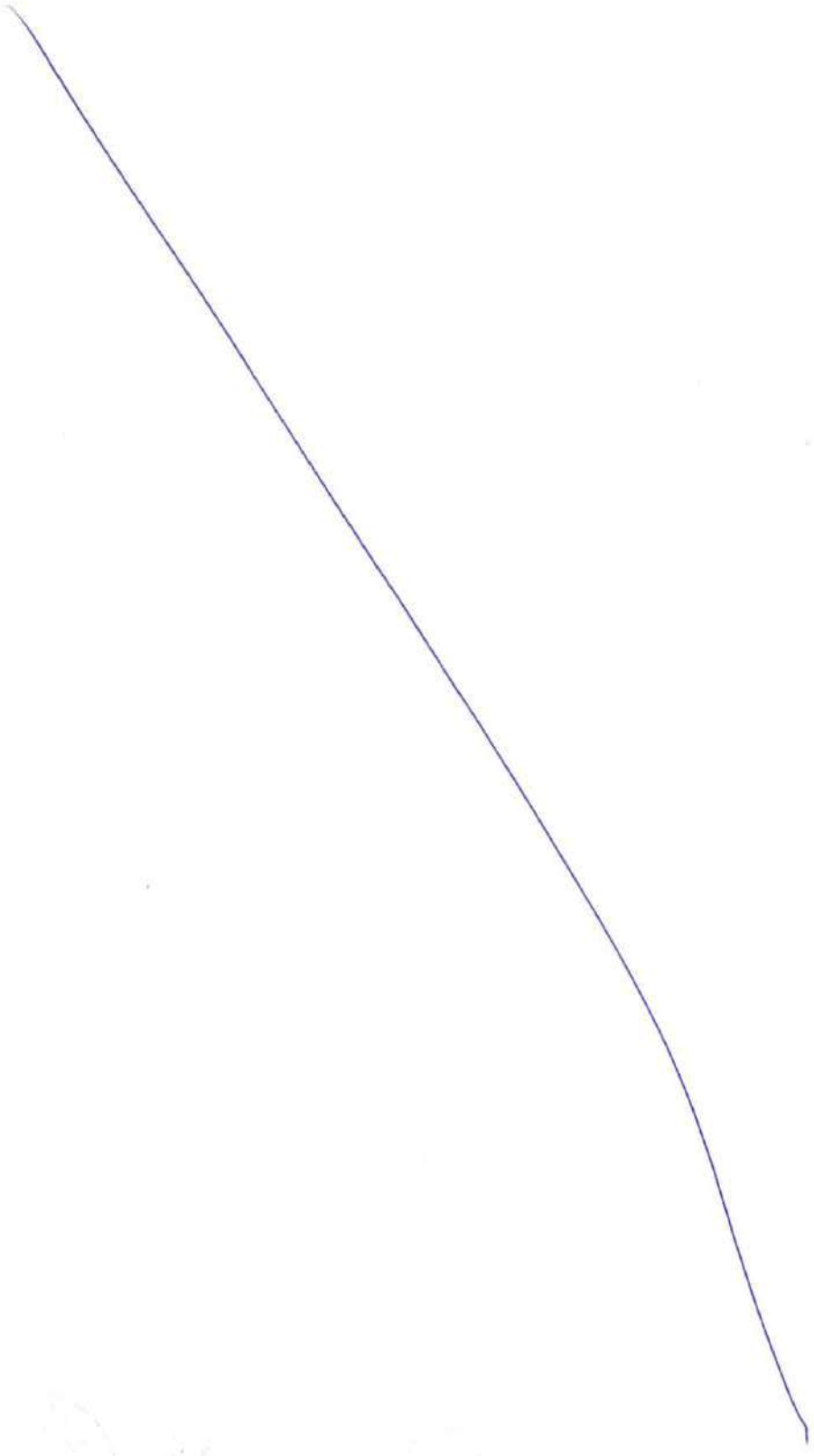
6.9 Implement action plans and measure the results. Identify areas of improvement & prepare corrective action plans.

6.10 Assess the risk in case of non-achievement of quality objectives, measure impact on organization scope and deliverables.

6.11 Report progress in management review meeting and follow improvement plans.

7. RECORDS:

1. Quality objectives - WP 01 F01
2. MOM of Management Review Meeting - WP 05 F01



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Quality Assurance Plan

Reference ISO Clauses: 6.2, 7.5, 8.2, 8.5

1. **TITLE : Procedure for Control of Documents**

2. **PURPOSE:** To establish and maintain a documented procedure for preparation, review, approval, issue, revisions, re-approvals and removal of obsolete documents. To ensure right documents at all times at point of use.

3. **SCOPE:** Project Quality Plan

4. **REFERENCE :** Procedure for: Planning of QMS & Quality objectives Control of Records

5. **RESPONSIBILITY: PRIMARY:** QMS Co-coordinator (SITE) for sections 6.2, 6.3 & 6.5; Planning Engineer for section 6.4

   SECONDARY : All dept. heads

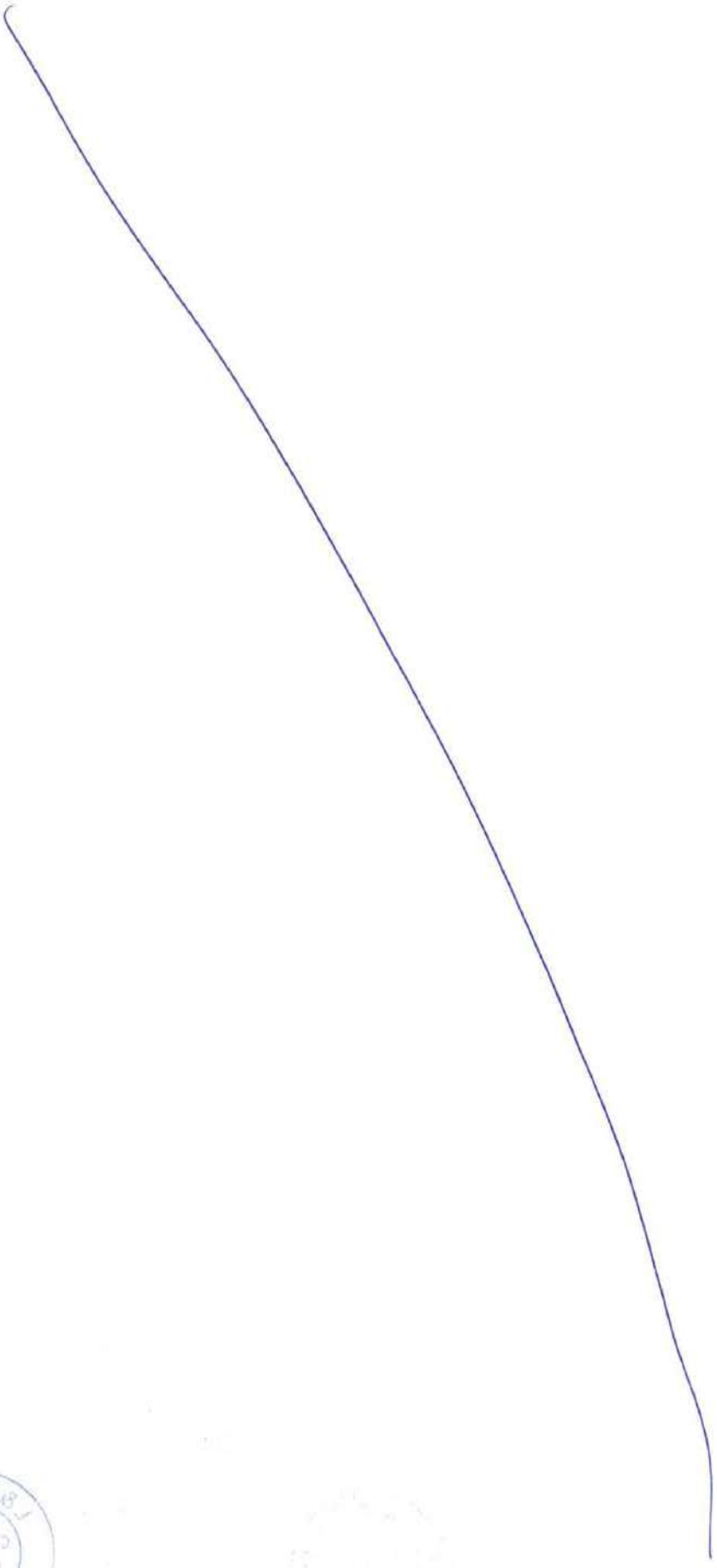
6. **PROCEDURE:**

6.1 GENERAL:

- Identify the type of document to be controlled.
- Identify the process owners to control the documents
- Ensure that the obsolete documents are removed; destroyed and only current documents are available with identified persons.

6.2 ISSUE AND CONTROL OF QMS DOCUMENTS

- Prepare Project Quality Plan (which includes work methods, ITP detailing responsibility, frequency, acceptance criteria and record to be maintained) in line with the following document:
  - Contract document
  - Model PQP
  - Applicable standards & Codes of practice
- Obtain 'Review and Approve' the PQP, from Project In-charge.
- Obtain approval from customer, if required contractually.
- Take prints/copies of approved QMS documents and stamp as 'Master copy'.
- Issue applicable PQP procedures stamped as "controlled copy" in front and maintain record of issue.



- Obtain approval and re approvals of changes/revisions as necessary.
- Maintain controlled copy list.
- Verify revision status as per the distribution list of documents and file the latest revision of documents and destroy the superseded copies.

6.3 DOCUMENT CHANGE

- Receive inputs through management review meeting/ internal audits/ Customer suggestions/ additions or Changes in specification / Document change note from users.
- Review the requirement of document change, discuss with PI / Department Heads and revise document. QAPs, IPTs & Work methods as and when required are prepared and approved and added to PQP. The list of Work procedures is maintained.
- Ensure superseded copies are destroyed except the Master copy. Issue the revised document to controlled copy holders.

6.4 CONTROL OF DRAWINGS:

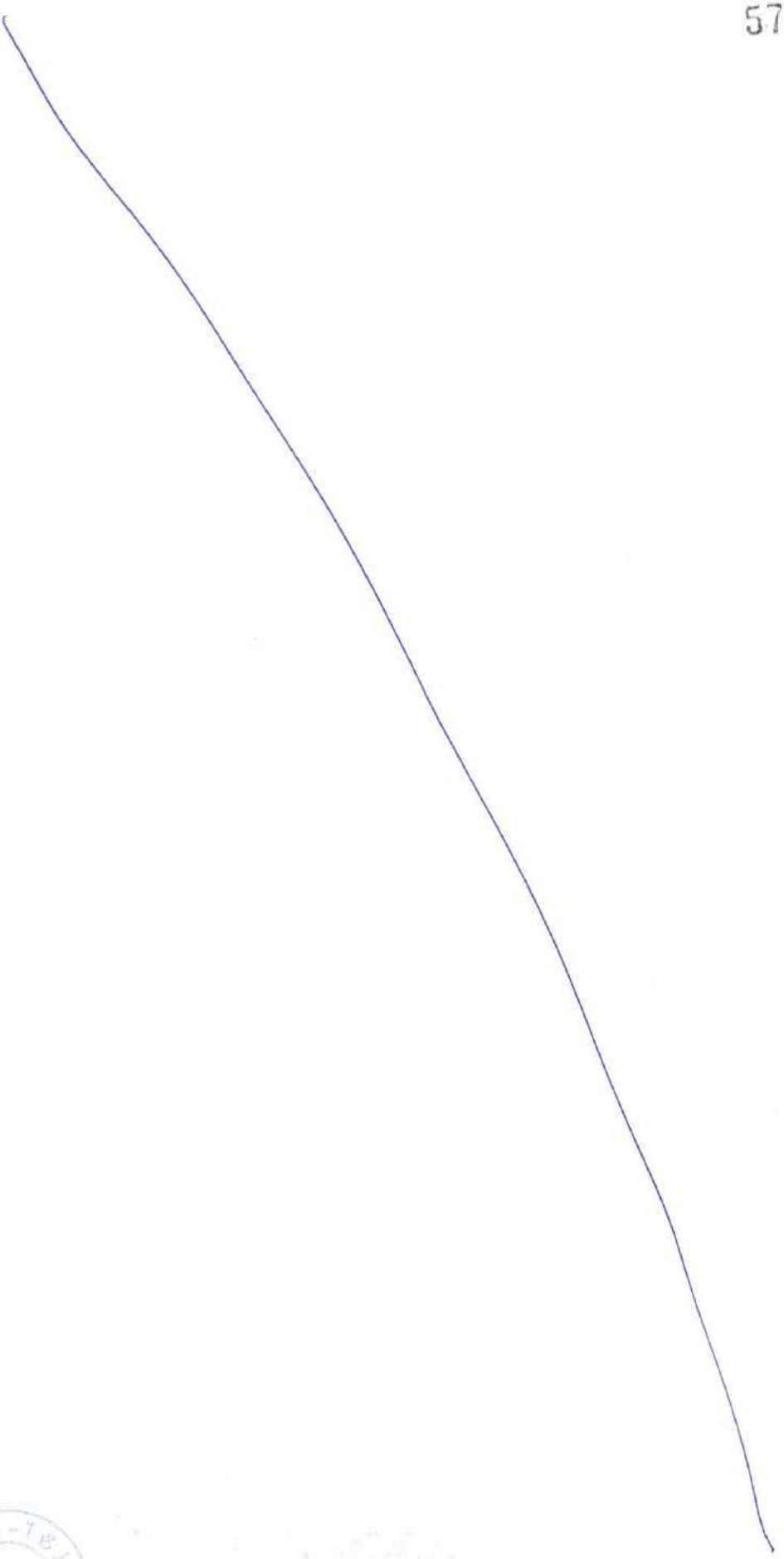
- Receive drawings and mark entry in the drawings register (soft or hard copy).
- Stamp the drawing as master copy.
- While issuing of drawings to users Stamp the drawings as "controlled copy".
- Maintain drawings issue register showing issue of drawing to particular users.
- The when drawings get updated / changed, Stamp them as "superseded copy" on superseded drawings of master copy and file them separately.
- Withdraw the superseded drawings from site and destroy the same.

6.5 CODES & STANDARDS:

- Control applicable standards and update as and when required (at least once in a year) and inform all concerned.

6.6 OTHER DOCUMENTS:

- Maintain incoming letters, mails, fax register mentioning subject and date of receipt.
- Maintain out going letters, mails, fax register mentioning subject and date of despatch
- Identify Files as required and maintain file list for easy retrieval.
- Identify and maintain Receipt, storage and issue details of records.



7.0 RECORDS:

- Master List of Codes & Standards – WP 02 F 01

Note:

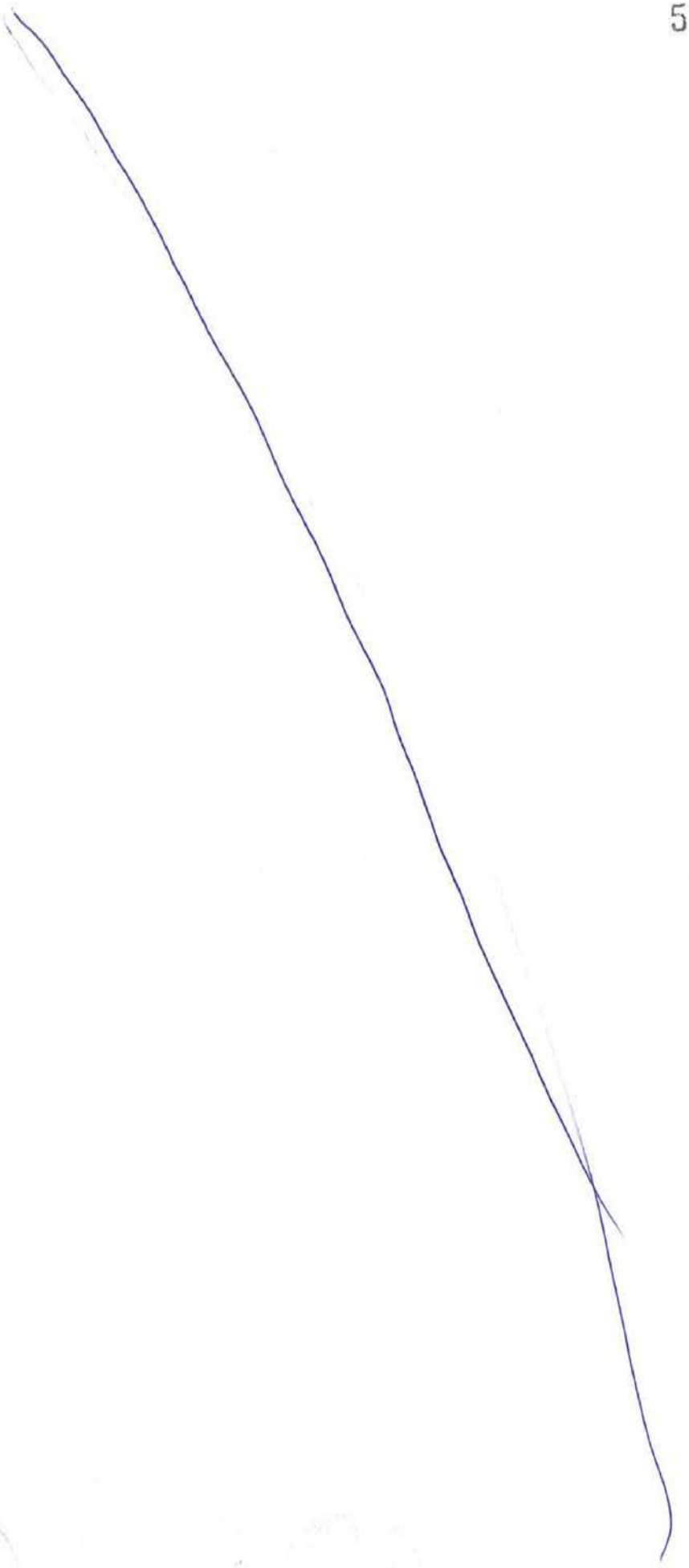
1) Typical list of documents and there retention periods are listed in PQP WP 02 WI 01
2) Work instruction for preparation of method statement/ work procedures (Refer: PQP WP 02 WI 02) provided for reference purpose.
3) This may be used as guideline in the absence of any specific customer requirement.

Reference ISO Clauses: 7.5, 8.1, 8.2

1. **TITLE** : **Procedure for Control of Records**
2. **PURPOSE** : To establish and maintain a procedure for control of record to ensure right Legible records at right place maintained in a traceable manner and protected in Safe manner
3. **SCOPE** : Project Quality Plan, contract, Correspondence
4. **REFERENCE** : Procedure for: Quality objectives, Document control
5. **RESPONSIBILITY** : **PRIMARY:** All department heads; **SECONDARY**: QMS coordinator (SITE)
6. **PROCEDURE:**

6.1 GENERAL:

- Identify the processes, whose records are to be maintained and prepare list of records
- Identify and establish the frequency / period of reviewing the data and its retention time.
- Ensure all input and output records of processes, reviews, action reports are
- Legible



- Not tarnished
- Numbered & filed properly
- Easily retrievable
- Update the master list periodically.

6.2 CORRESPONDENCE:

- Receive correspondence, enter details in computer or register
- Mark appropriately as below
- Action by
- Reply by (indicate date)
- For reference
- File
- Distribute to the concerned department for taking action.

6.3 DATA AND RECORDS IN ELECTRONIC MEDIA:

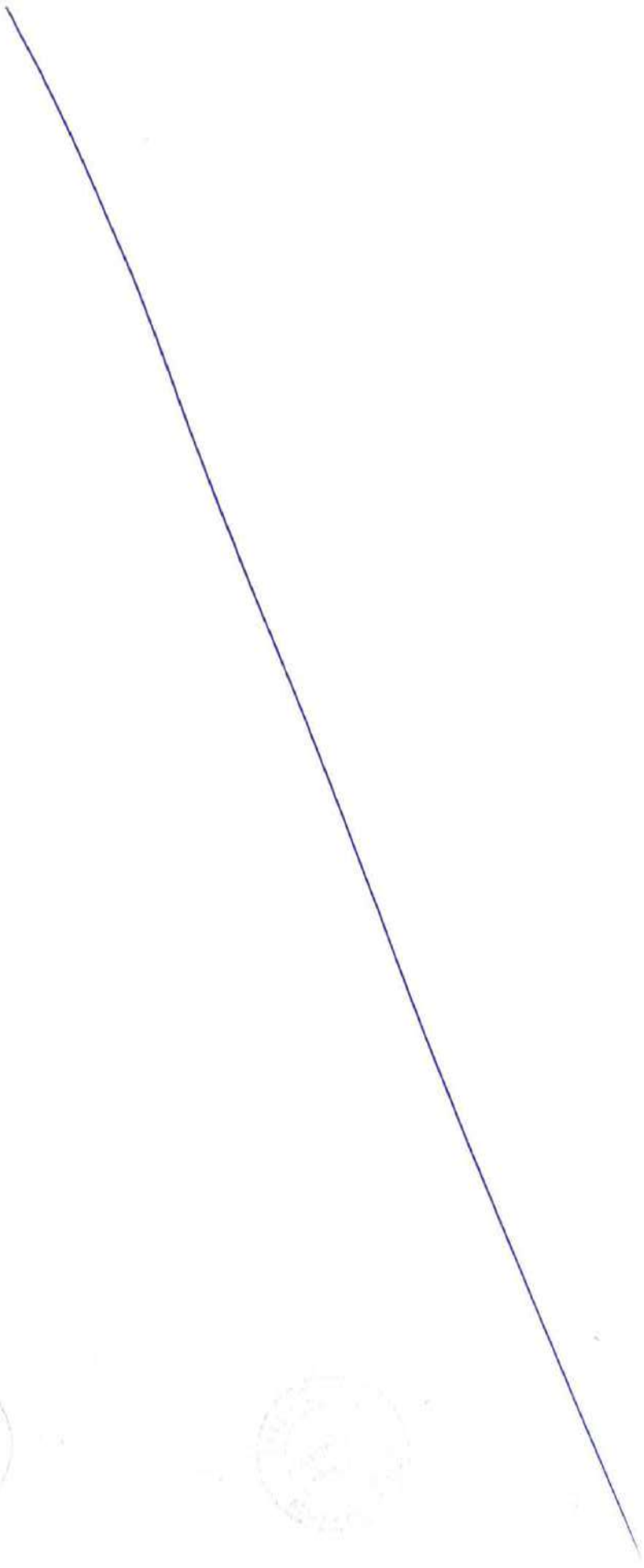
- Maintain a list of documents/ records in electronic media and back up details of important files as decided by users.
- Ensure storage & preservation of electronic media and back-ups kept in other building (in CD, DVD, server or other network PC),to avoid damage/ deterioration and to protect the of confidentiality.

7. RECORDS:

Master list of records - WP 03 F01

Note:

1) Typical list of records and there retention periods are listed in PQP WP 03 WI 01



Quality Assurance Plan

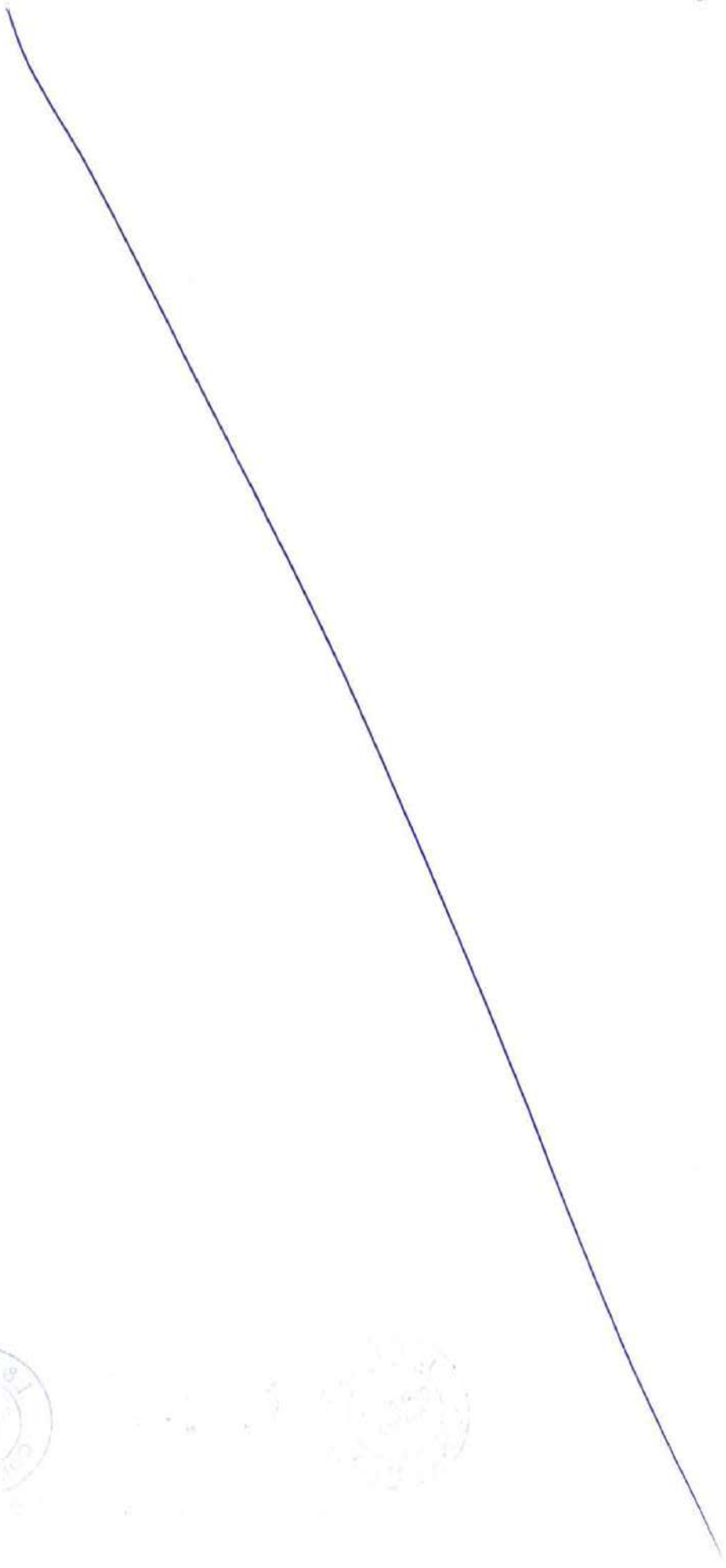
Reference ISO Clauses: 5.3

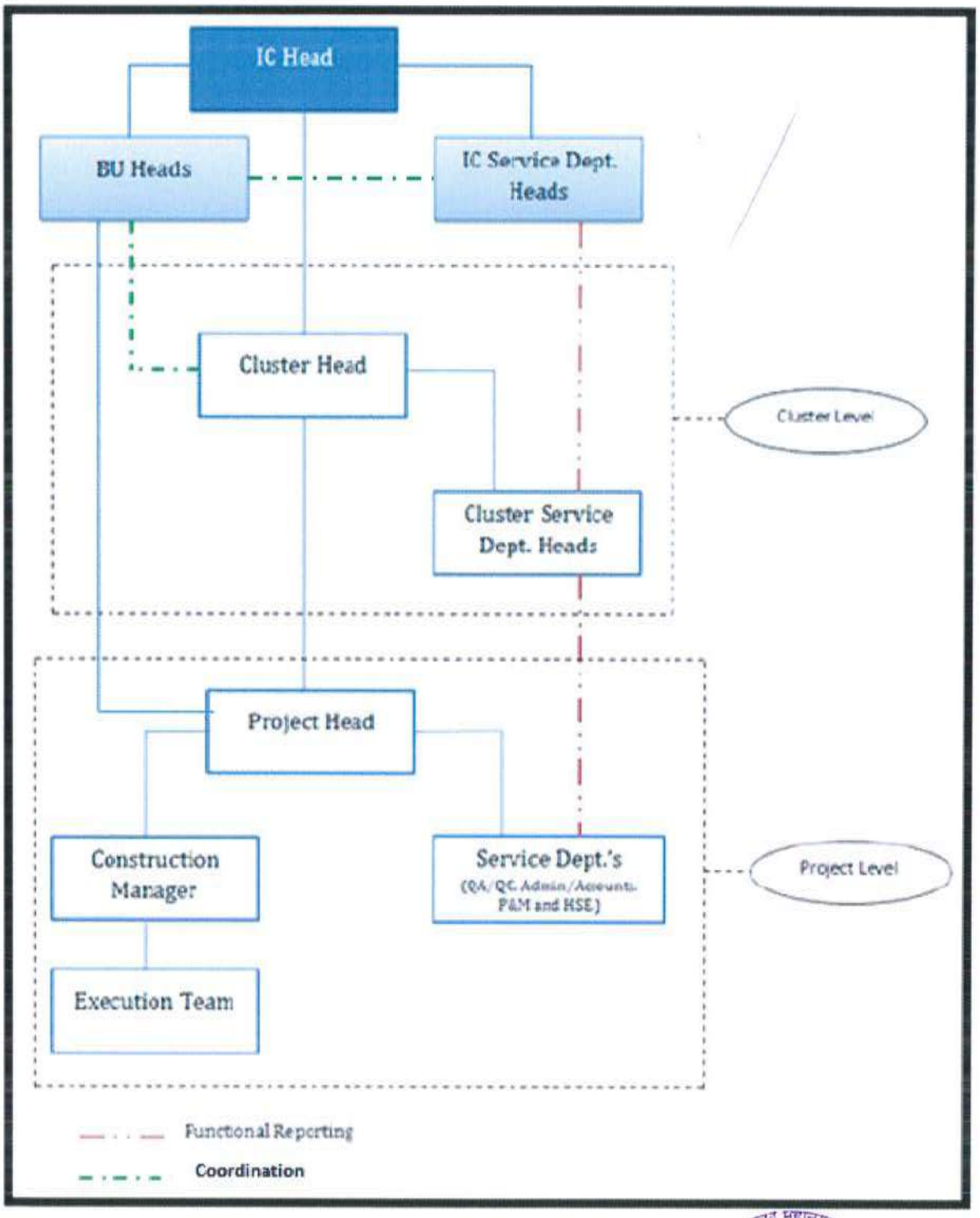
1. TITLE	**: Procedure for preparing organization chart with roles and responsibilities**
2. PURPOSE	: To establish roles and responsibilities of staff and the flow of information to meet customer and organization's goals.
3. SCOPE	: All activities at project.
4. REFERENCE	: Contract, Procedure for Document control, Procedure for Record Control
5. RESPONSIBILITY	: **PRIMARY** : Project in-charge **SECONDARY**: Planning In-charge

6. PROCEDURE:

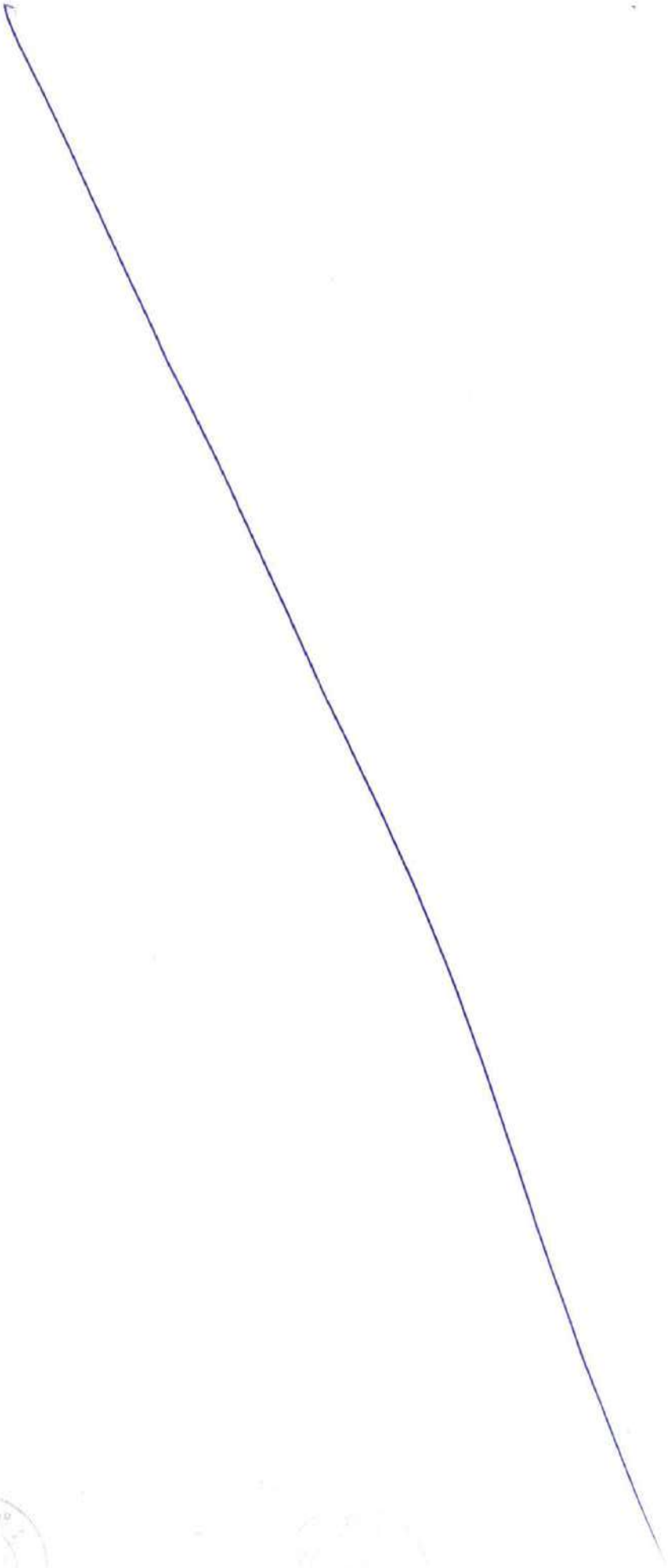
Organisation chart with key positions marked for implementing / managing the Quality system Project level is as below:

Project in-charge shall issue a separate note, when a key staff is out of station (duty) or on leave or released from site about delegation of his responsibilities to others.

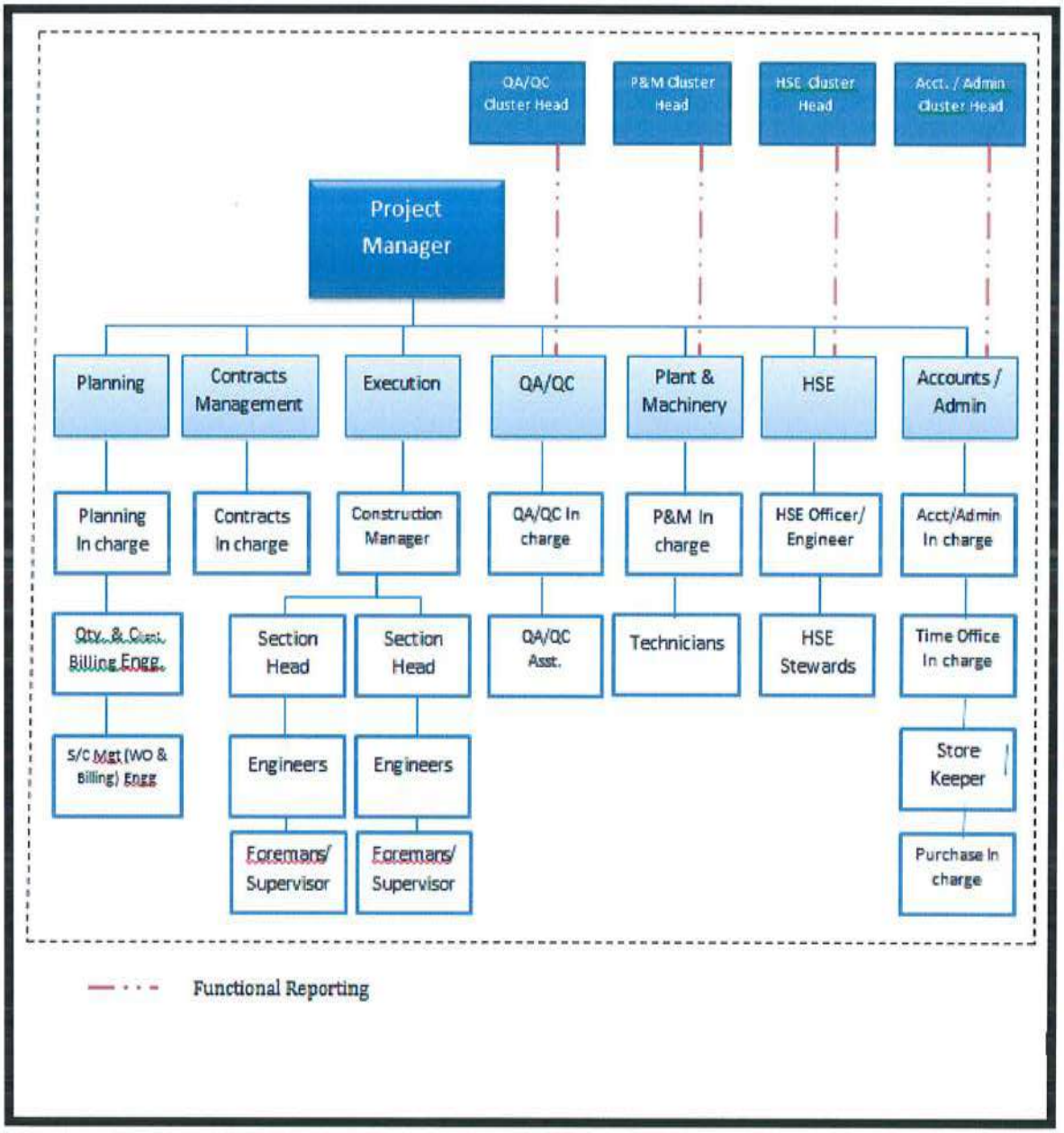




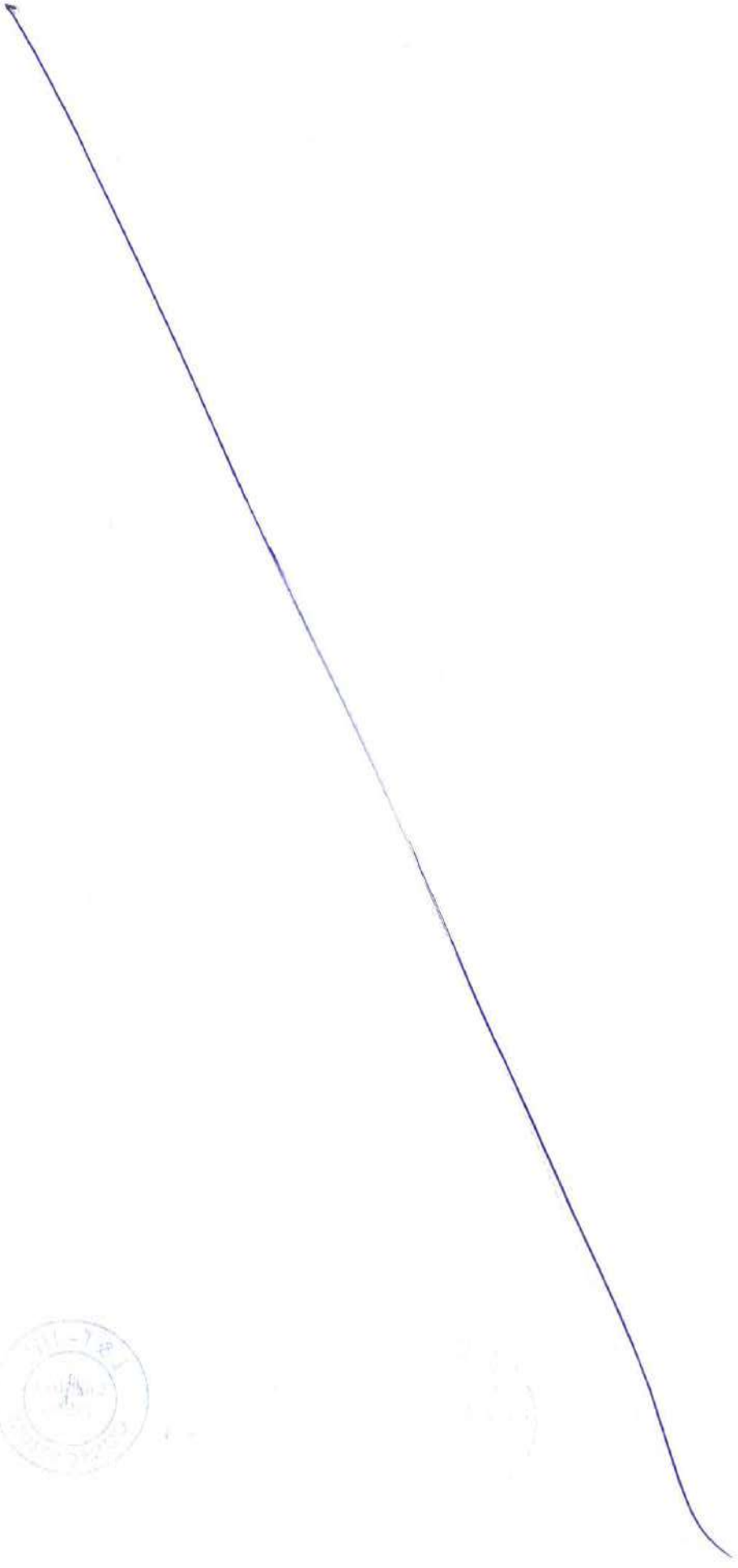
Organization Chart for Cluster to Project Level



Quality Assurance Plan



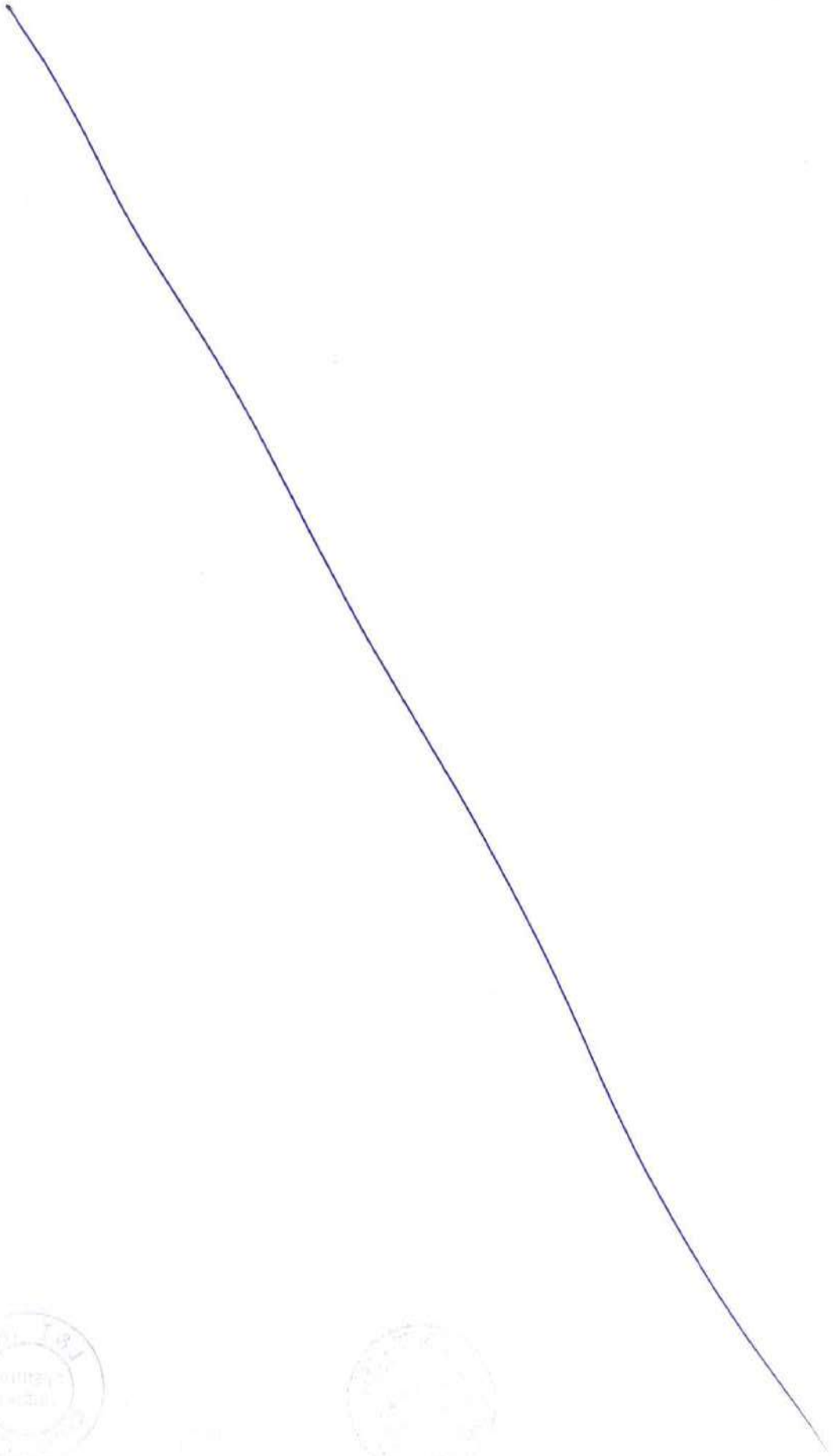
Organization Chart for Project's



Quality Assurance Plan

PROJECT SPECIFIC ORGANISATION CHART SHALL BE PREPARED IN LINE WITH CONTRACT AND INCORPORATED HERE.

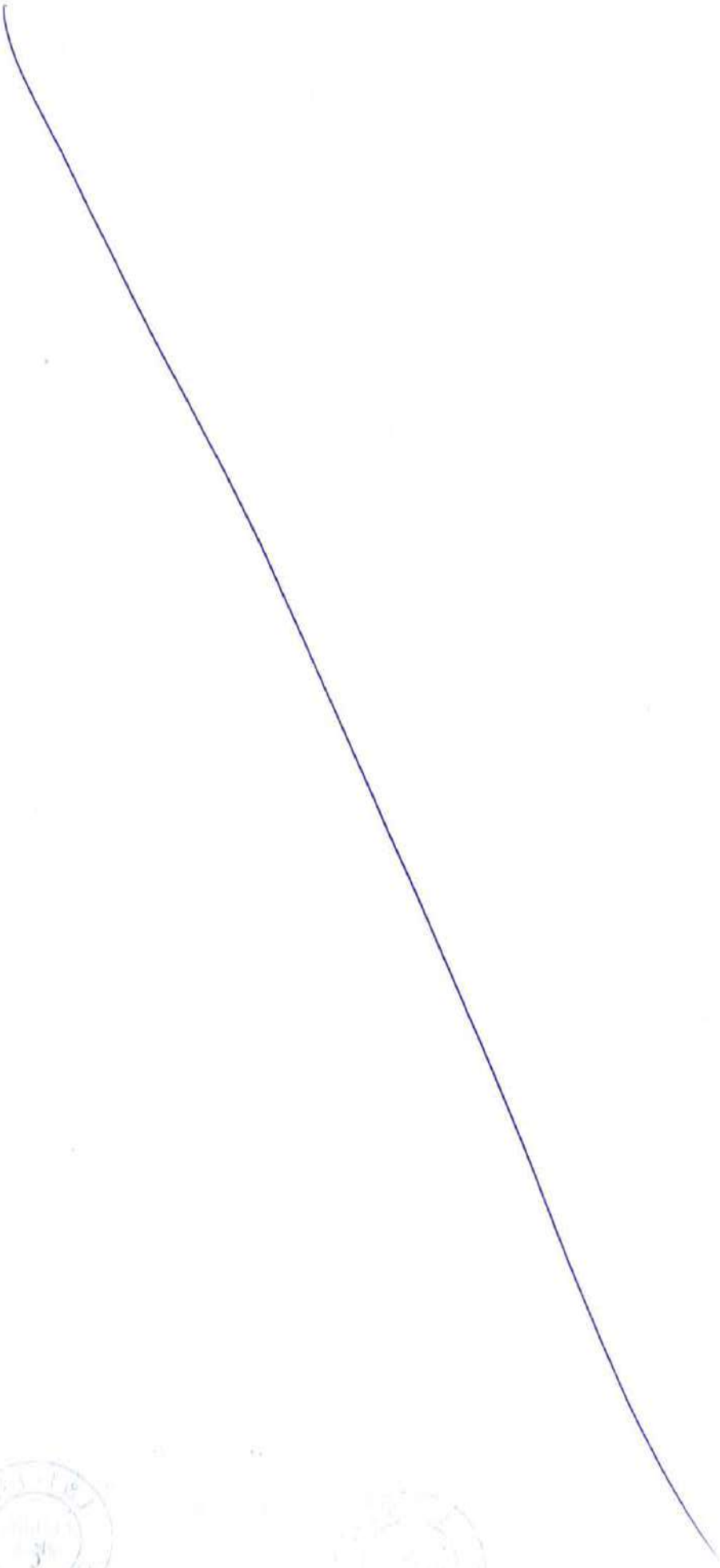
(The organization chart should clearly show all the important positions/ departments, Sections and functions including service functions like MR (site), Quality Department, Safety, P&M, etc. If required the organization chart can be split into more than one chart for better clarification & identification. The organization chart should be with revision no. and date and should be updated whenever any change in site organization occurs).



Quality Assurance Plan

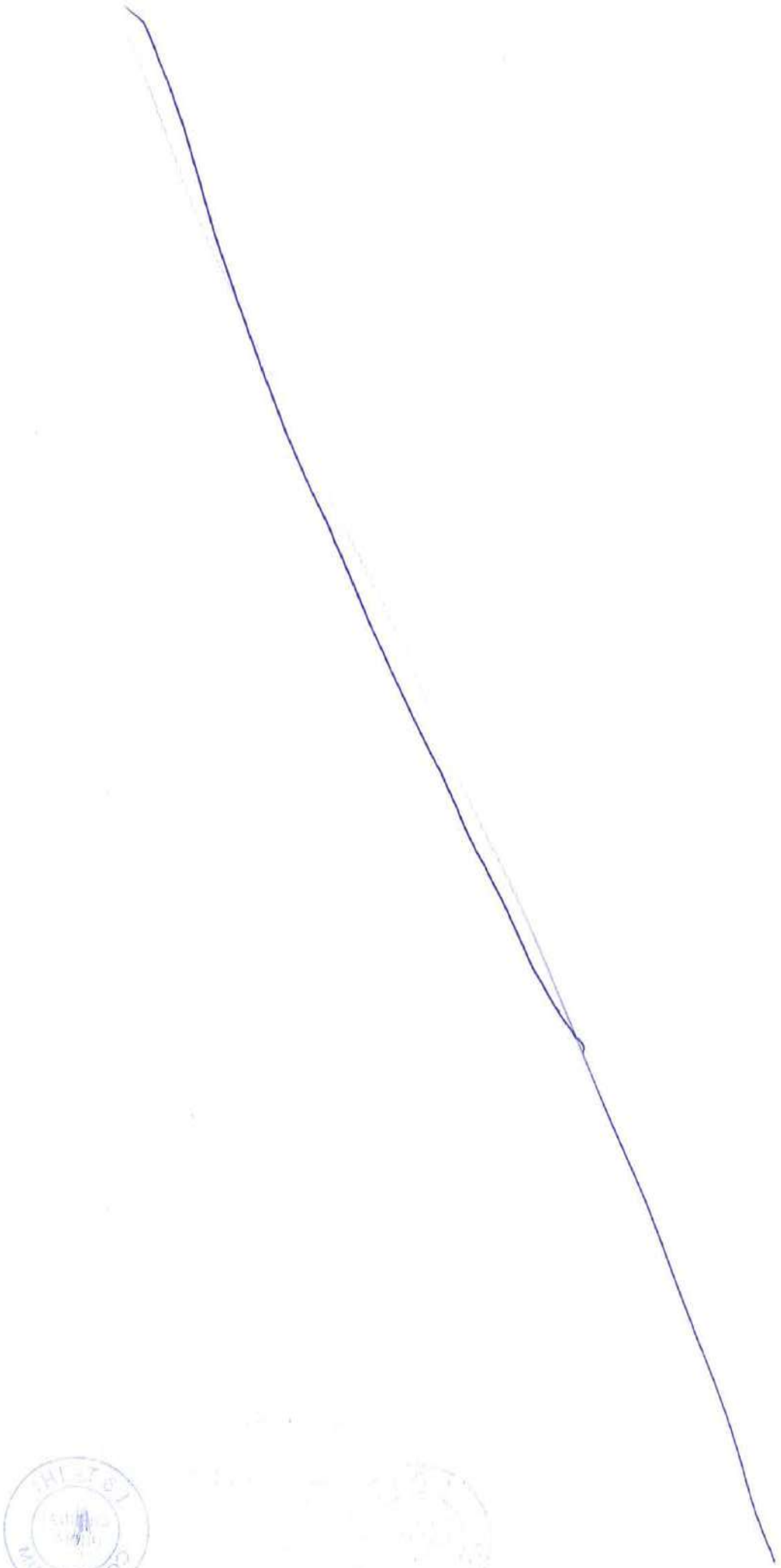
The responsibilities & Authorities of various functions are mentioned as below: If a staff is performing multiple functions shall be responsible for the respective functions.

Department/ Position	Role & Responsibility
At Cluster Office	
Cluster Head	- Take accountability for the effectiveness of the quality management system - Promote the use of process approach and risk based thinking - Communicate the importance of effective quality management and conforming to the quality management system requirements - Engage, direct and support persons to contribute to the effectiveness of the quality management system - Promote improvement - Ensure that the resources needed for the quality management system are available - Support other relevant management roles to demonstrate their leadership as it applies to their areas of responsibility. - Collate the shortcomings in existing work methods at sites and resolve. - Identify new work methods required for operation and inform HQ. - Collect client requirement on technology requirements and discuss in RMC and inform HQ through minutes. - Implement at site improved / developed / acquired work methods and technologies and fine-tune. - Collect market information in the area and keep management informed. - Collect competitor's intelligence on their strategies / working at site. - Engage in continuous interaction with both existing & prospective customers. - Prepare tenders of value as per management guidelines. - Inputs to HQ in tender preparation. - Pre & Post tender follow up for all tenders.

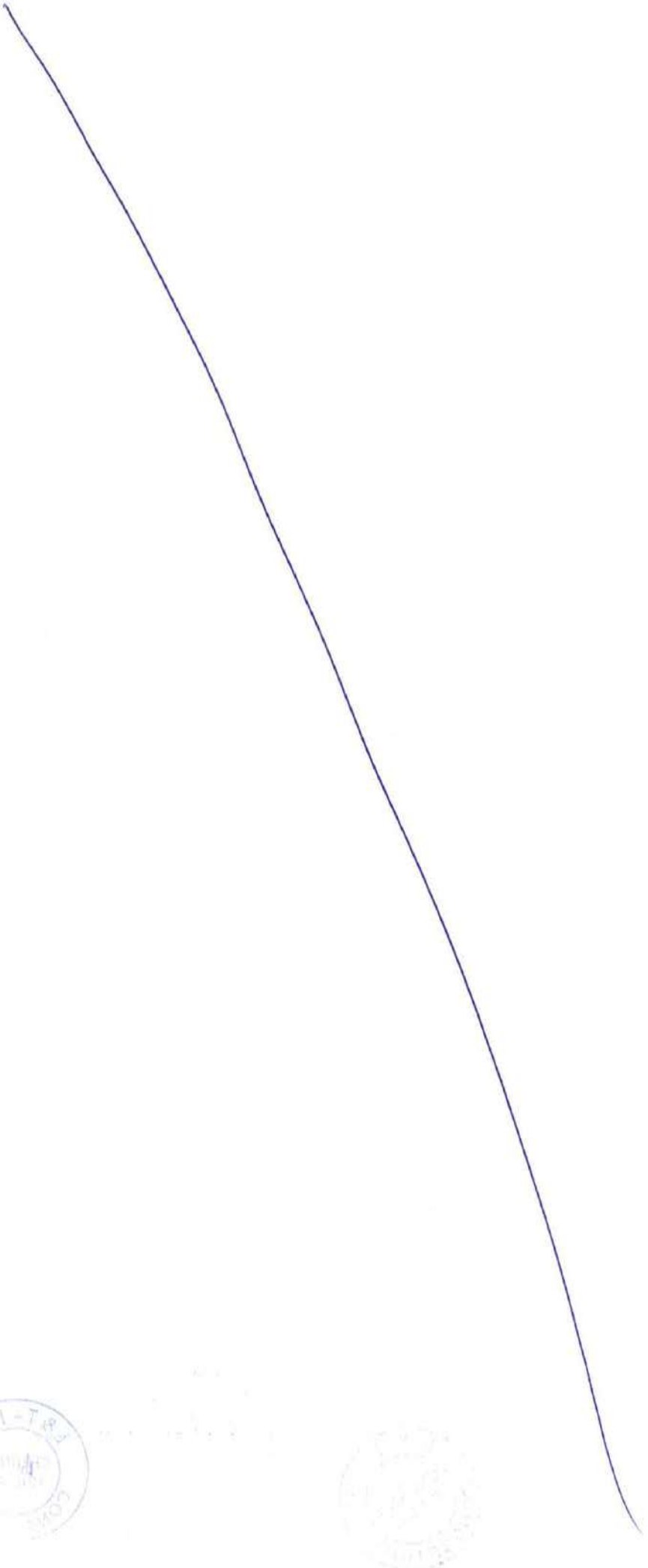


Quality Assurance Plan

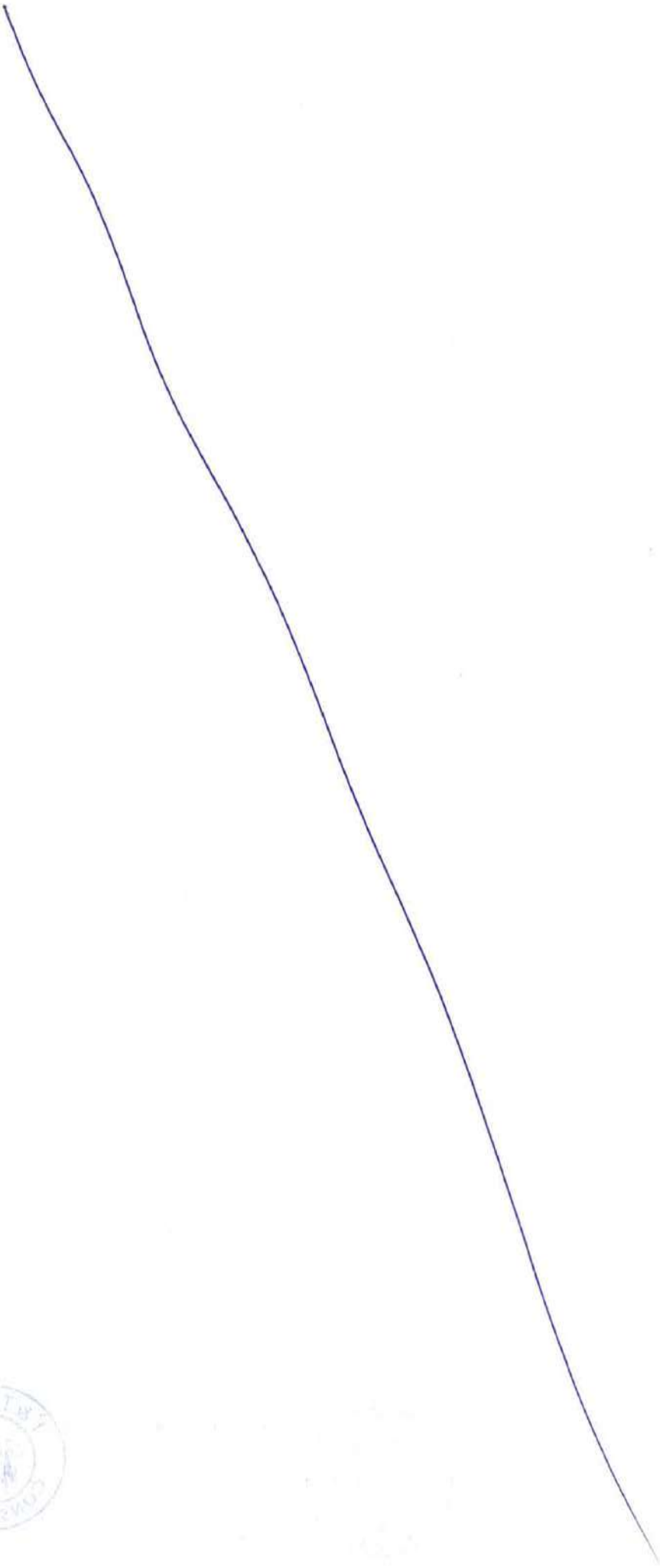
	- Organize Kick-off meeting. - Monitor site operations, variance analysis and course correction. - Approval of ACE. - Approve / arrange approval of WO, PO as per management guidelines. - Human Resource Development – Nurture leaders. - Sub-contractor development.
Cluster Materials Manager	– To discuss with suitable domestic vendors (from out of registered vendors & other specialized agencies) and finalize the purchase orders for construction materials, supply items, construction equipment etc. Regional-Materials will take. – Procurement action for items (materials) decided in the internal kick off meeting.
Cluster Plant Manager	– Responsible and accountable for overall P&M Department operations in his jurisdiction. – Jurisdiction of Cluster project manager is highly dynamic which is depending upon the Location of the project, Job concentration in a locality, intensity & criticality of the project – Cluster project manager may be assigned with multiple projects or a unique project. – Reduce idle equipment population at sites by – Ensuring faster repairs to equipment under breakdown – Redeployment of idle assets at project sites – Inform to Head – P&M and IC-Resource Head on Project requirement and surplus assets in every month and – Taking timely disposal action for uneconomical plant and equipment – Ensure timely equipment deployment as per customer's requirement – Establishment of site P&M workshops and equipping them with necessary workshop machines, tools and tackles – Monitoring of equipment operation, maintenance and repairs at site – Preparation of P&M cost estimate - site wise – covering spares, labour, staff and external repairs cost – Collection of data regarding P&M Department operations viz.



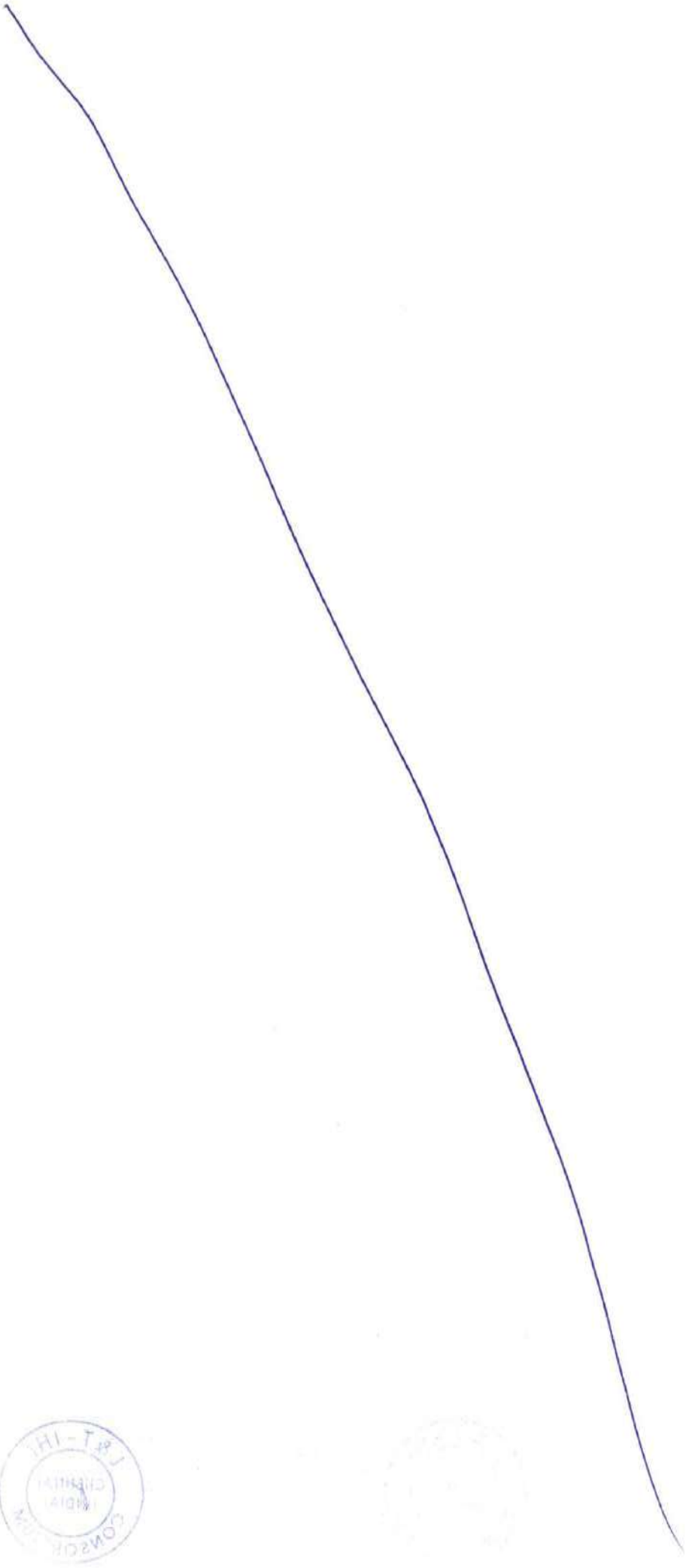
	Availability, utilization, costs and analysis for taking corrective actions – Planning and deployment of P&M staff to meet requirement at sites and interact with Head – P&M for inter site / BU transfer as and when required.
Cluster Safety Head	– Understand the L&T-IHI Consortium EHS Integrated Management System (IMS) including appropriate internal and external standards and ensure strategies are developed for implementation throughout all operations. – Make recommendations to the appropriate management on all matters relating to EHS. – Advise the IC EHS Head and Cluster Heads areas of weakness within the EHS IMS and implementation of the system. – Understand & promote L.I.F.E. (Living – Injury – Free – Each day) program and Zero Harm Vision. – Ensure L.I.F.E. (Living – Injury – Free – Each day) EHS leadership training program is delivered throughout the cluster. – Support project set up and early mobilization. – Coordinate deployment of all senior permanent and contract EHS staff within the cluster. – Stop work if unsafe practices are witnessed and promote a 'Don't Walk by & Commitment to Action attitude' at all times. – Co-ordinate all L&T-IHI Consortium & Infrastructure Cluster EHS matters by receiving regular reports, making EHS visits, and ensuring that information is circulated to keep all concerned fully informed. – Develop audit planning strategies and carry out EHS audit at least once every 6 months on every project within the cluster. – Provide EHS reports to the IC EHS Head and Cluster Head to inform them of the status of cluster EHS performance. – Co-ordinate the activities of independent EHS Consultants. – Support project incident investigations and review reports prior to issue to management. – Attend all fatal incidents and support the investigation. – Collect and collate incident and near miss reports and records, review, prepare reports and distribute information on EHS



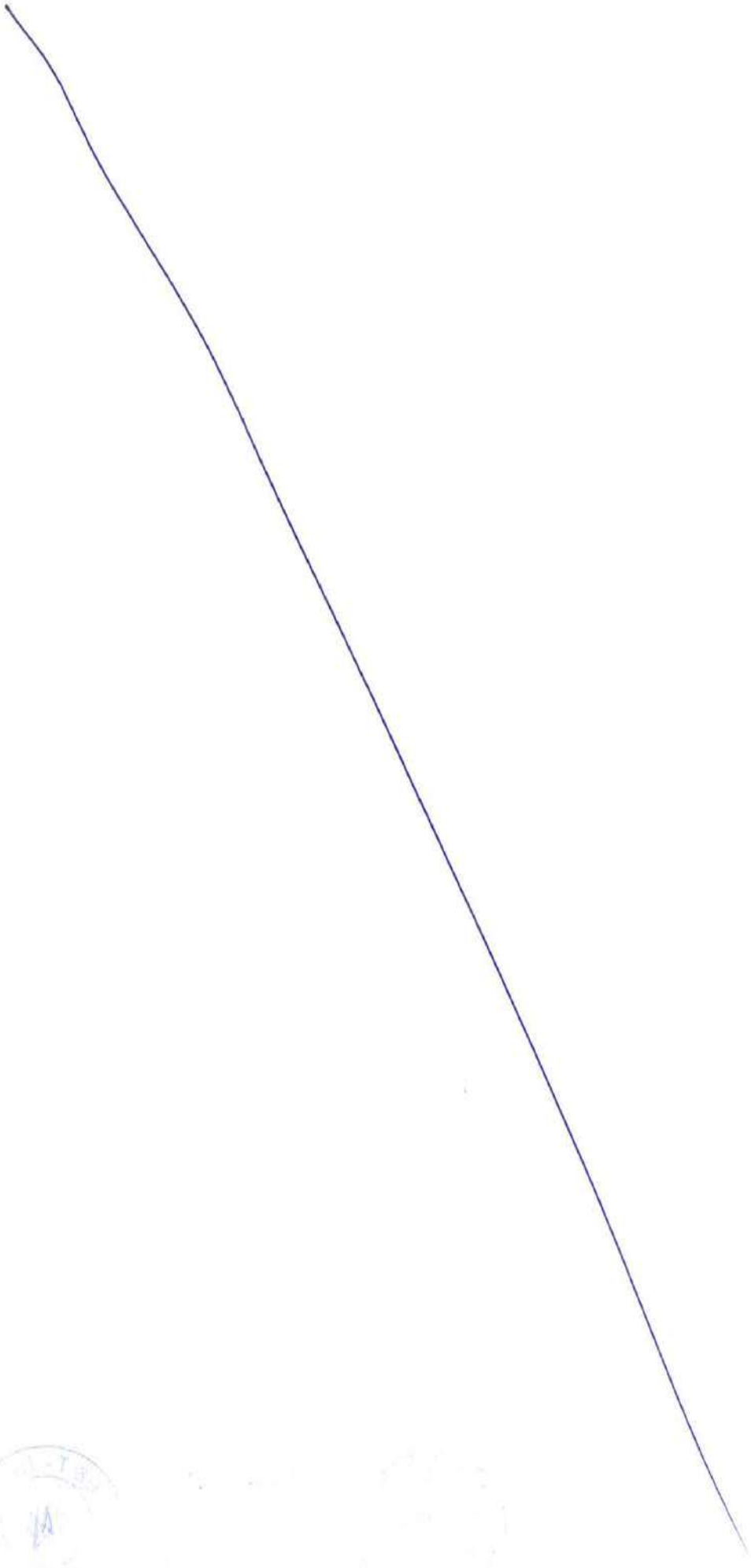
	matters relative to the prevention of incidents and matters relating to general EHS performance to L&T-IHI Consortium & Infrastructure to IC EHS Head and cluster Head. – Maintain effective communications with the IC EHS Head, cluster Head and EHS personnel to ensure an adequate flow of EHS information relating to the EHS performance. – Attend meetings when requested – Coordinate monthly meetings with Project EHS Managers. – Monitor the provision of EHS training and advice on training requirements. – Deliver EHS training when requested. – Liaise with the HR function and EHS training function to ensure that records of training are fully maintained within the cluster. – Provide input into the tendering process to ensure that statutory requirements are planned into projects at the earliest opportunity. – Visit projects on a regular basis, meeting with the project leaders, JV partners, clients and report to the IC EHS Head and cluster Head of the findings – Accompany cluster Heads on EHS Tours every quarter. – Use disciplinary procedures in consultation with the IC EHS Head, cluster Head & HR Head if any employee or contractor is careless with regard to their own or others EHS
Cluster Quality Head	– Assist Cluster Head in • Ensuring that the quality policy and quality objectives are established for the quality management system and are compatible with the context and strategic direction of the organization • Ensuring the integration of the quality management system requirements into the organization's business processes • Ensure that the quality management system achieves its intended results - Identify the good practices and cascade to all the sites. - Measure product Quality and ensure continual improvement. - Interact with customer on Quality related issues and report to Head cluster and Head Quality - HQ. - Receive Monthly Quality Report (MQR) of all sites and Review, Analyze and suggest project sites for Quality Improvement



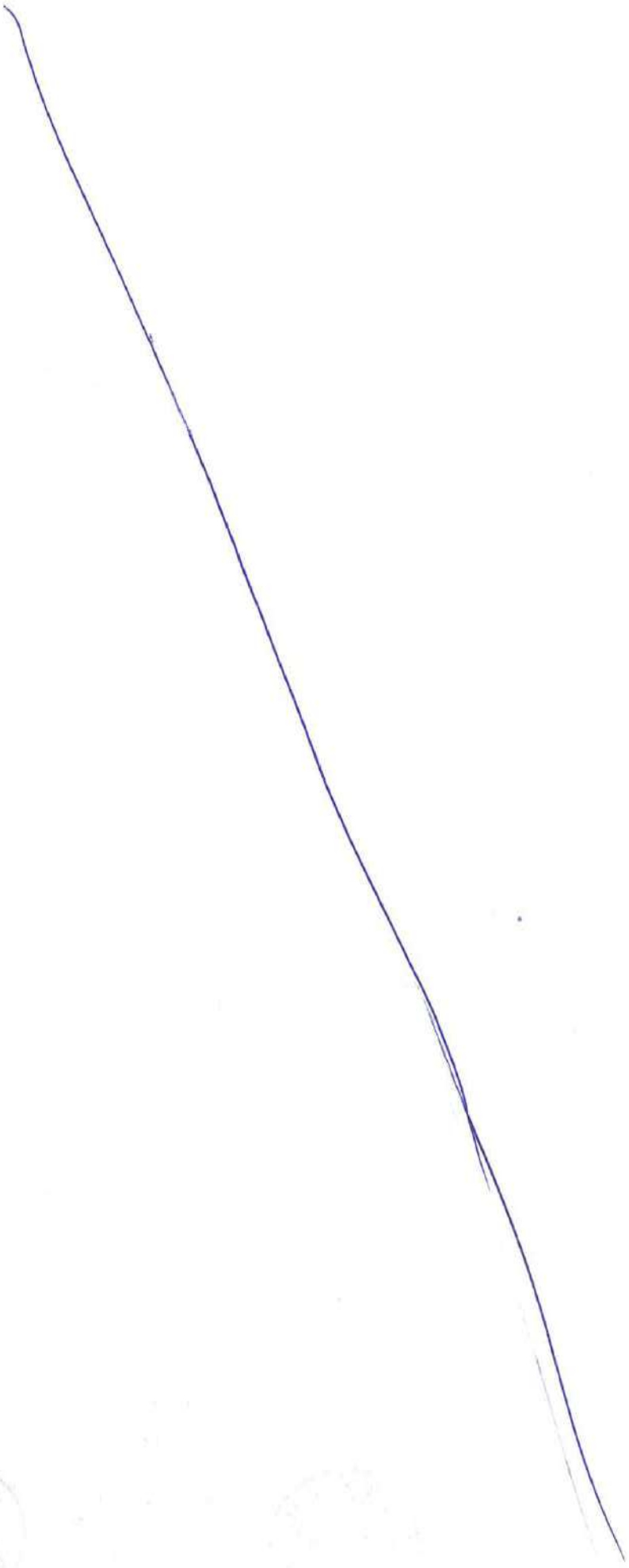
	continually. - Co-ordinate with project sites on day to day basis and provide necessary support to ensure the Quality of Product. - Ensure receipt of customer feedback on Quality for n every month as a part of MQR. - Ensure QA support for all tender preparations for all BU's pertaining to cluster. - Support for preparation of PQP, work procedures, work instructions and ITP's – New projects. - Ensure system implementations as per Procedure at all levels in cluster and coordinate with internal and external audits. - Ensure QA/C staff adequacy and accountability at projects. - Conduct meeting at cluster with site QA heads at planned intervals/ Prepare MOM/Circulate to all sites with a copy to HQ. - Training for Quality Gaps. - Coordinate for procurement inspections including vendor assessment. - Ensure Cluster Quality Objectives reviewed as per the stated frequency and drive for achievement.
At Site	
Project In-charge	– Take accountability for the effectiveness of the quality management system - Promote the use of process approach and risk based thinking - Communicate the importance of effective quality management and conforming to the quality management system requirements - Engage, direct and support persons to contribute to the effectiveness of the quality management system - Promote improvement - Ensure that the resources needed for the quality management system are available - Support other relevant management roles to demonstrate their leadership as it applies to their areas of responsibility. – Organize & manage all resources and field activities to achieve an efficient and effective completion of the contract, within the agreed time and cost, whilst paying due regard to safety and meeting Quality requirements. – Accountable for Quality / productivity improvements through



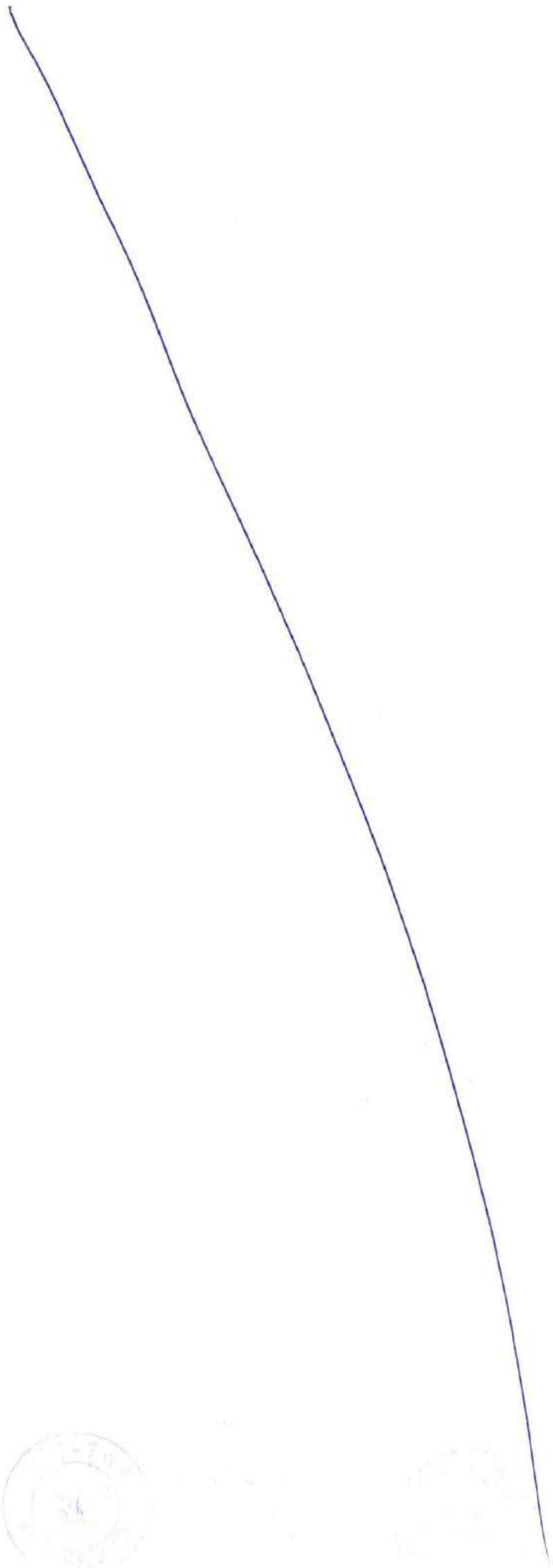
	process changes – To sort out issues escalated by site MR on site process, QA/QC on product quality – Roll out major programs / process changes – Give feedback on monthly reports from site MR and planning engineer – Preparation and implementation of Project Quality Plan, Liaison with Customer, Regional, Head Office and local authorities. – Negotiation with S/C and suppliers for fixing rates. – Improving Customer satisfaction including handling customer complaints
Construction Manager	– Prepare Daily, weekly and monthly schedule as per 3 months look ahead program in consultation with planning engineer. – Allocate the resource for activities as per the schedule – Preparation and Implementation of Work procedures. – Implementation of PQP – Planning training requirements and arranging for training to site staff, Supervisors at site level.
Planning In-charge	– Integration of project schedules for all works & monitoring. – Preparation of Accepted Cost Estimate and review through Job Cost Report at regular intervals. – Contract review, process control and service requirement – Coordinate with Cluster/ HQ for arranging required materials & resources in time. – Synchronize the activities of all departments to achieve the planned cycle times/ overall schedule – Arranging required information to Customers regarding project control & progress monitoring as per contract – Arranging required information to Cluster/ HQ about project as per PMS & MPCS
Planning Engineer	– Preparation of MPCS schedules and ACE – Monitor the progress & the cycle times for different activities of work – highlight variances – Preparation of Accepted Cost Estimate and review through Job Cost Report – Preparing actual schedule of resources required based on achieved progress



	– Reconciliation of materials & resources and other technical reports
Billing Engineer	– Raising of invoicing on Customers as per contract – Preparation of work orders & amendments for sub contract works – Monthly preparation of S/c bills – Periodic reconciliation of Customers billing vs. S/C billing – Periodic reconciliation of materials
Contracts Engineer	– Thorough study & identification of contractual obligations of both parties – Develop the list & timing of obligations – Review & monitor the fulfillment – Preparation for issue of notices – Preparation of Customers correspondence
Section In-charge	– Ensure the construction activity as per approved construction & work methods. – Prepare survey plan – Ensure conduct of Quality checks. – Ensure completion of activities to meet the project time schedules
Erection Engineer	– Prepare construction method statements, flow charts, work methods – Prepare the theoretical cycle time for the activities – Conduct trials / mock up and fine tune methods/ cycle times – Obtain approval for the methods – Execute work as per approved method statements / work methods. – Prepare schedule of materials / plant requirement.
ISD coordinator	– Maintenance of hardware & software – Ensure timely rectification of any problems
Surveyors	– To establish control points as per survey plan. – Responsible for day to day survey activities and maintain records, during respective shifts – To carryout post construction survey and record as built status. – Conduct calibration of any survey equipment as per plan with QC Engineer.
Supervisor	– Prepare construction method statements, work methods and

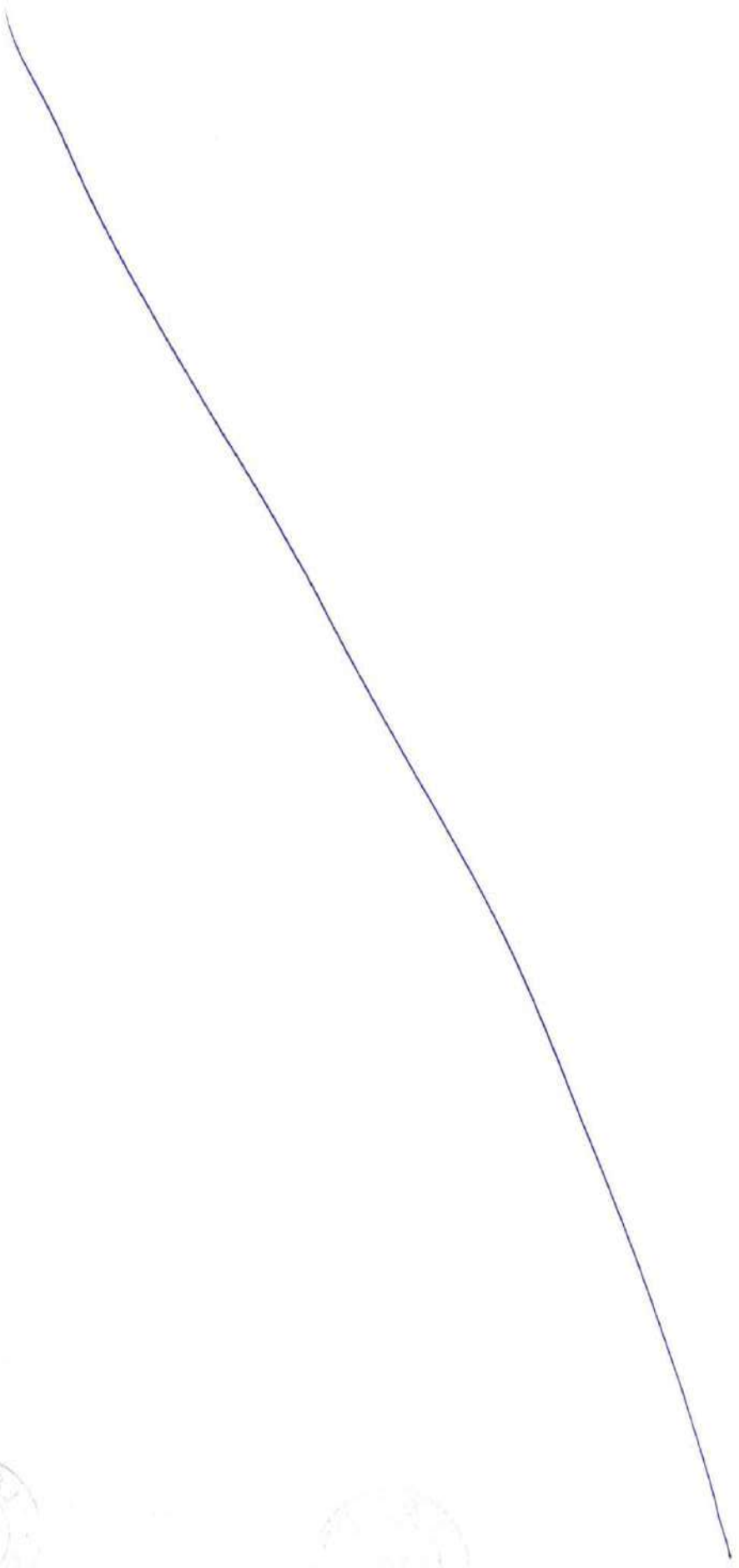


/FLS (Front line supervisors)	obtain approval for the same for civil works – Conduct trials / mock up. – Execute work as per approved method statements / work methods. – Prepare schedule of materials / plant requirement. – Ensure conducting all activities to meet the cycle time requirement for Area A – Front line supervision of the working labor to ensure strict conformance to methods, quality & safety
Execution Engineer	– Prepare construction method statements/ work procedures and obtain approval – Conduct trials / mock up. – Ensure execution of work as per approved method statements / work procedures. – Prepare schedule of materials / plant requirement. – Supervision of the working labor to ensure strict conformance to methods, quality & safety
Piping Engineer	– Prepare construction method statements, work methods and obtain approval for the same for piping works – Conduct trials / mock up. – Execute work as per approved method statements / work methods. – Prepare schedule of materials / plant requirement. – Supervision of the working labor to ensure strict conformance to methods, quality & safety
E&I Engineer	– Prepare construction method statements, work methods and obtain approval for E&I works – Conduct trials / mock up. – Execute work as per approved method statements / work methods. – Prepare schedule of materials / plant requirement.
Electrical Engineer	– Supervision of the Electrical works activities to ensure strict conformance to methods, quality & safety.
Instrumentation Engineer	– Supervision of the Instrumentation works activities.
P&M in charge	– Ensure continuous availability of P&M at site.

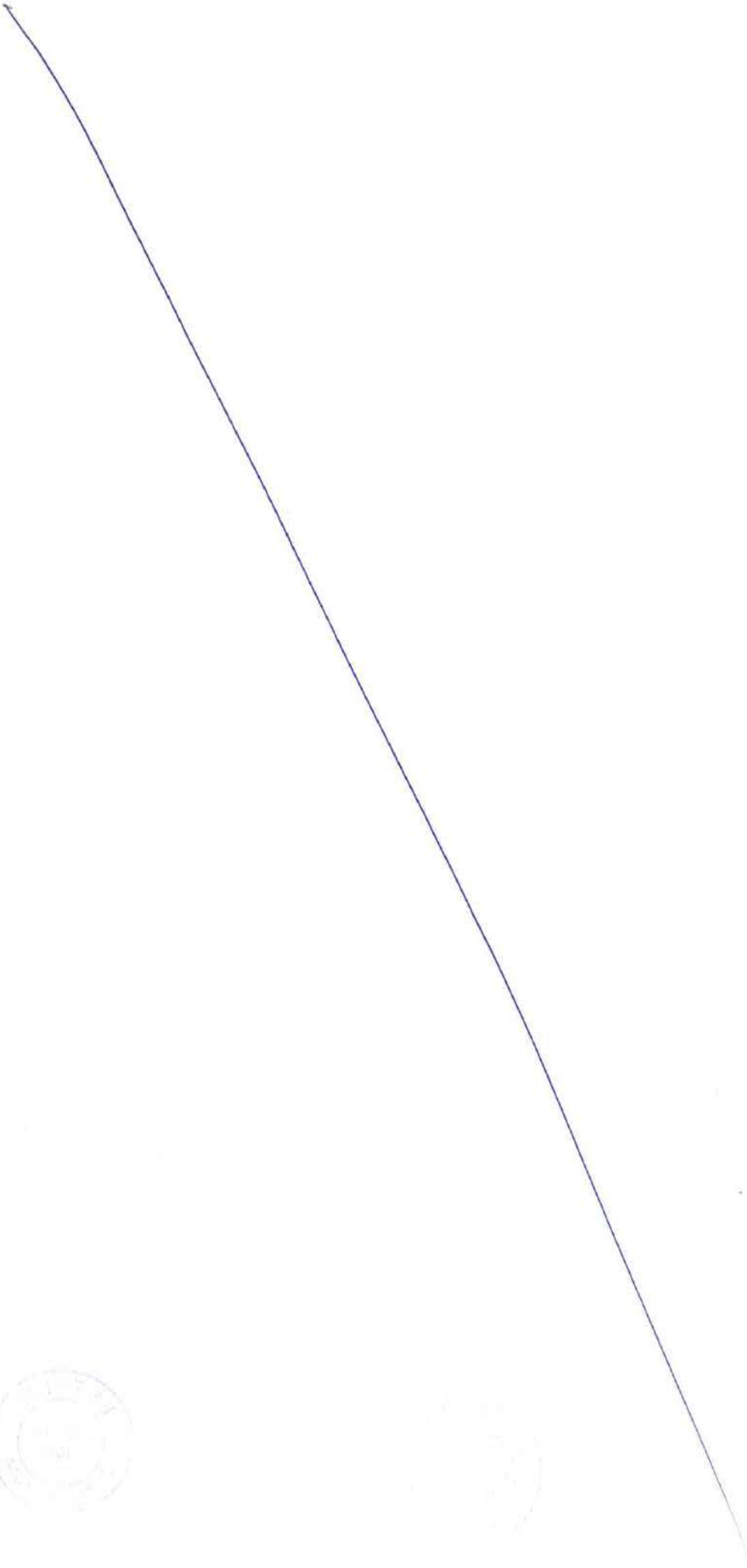


Quality Assurance Plan

	– Ensure periodic preventive maintenance & timely breakdown repairs of all machinery & electrical equipment as per their inspection manuals. – Ensure operation of P&M as per company norms
Repairs & Maintenance supervisor	– Preventive maintenance – Breakdown repairs; Reporting of required data related to repairs & maintenance
Operations supervisor	– Operation of P&M – Reporting of required data related to operation
EHS Engineers / EHS officers (EHSO)	– Carry out EHS inspection of Work Area, Work Method, Men, Machine & Materials, P&M and other tools and tackles. – Creating EHS awareness through Pep Talk. – Co-ordinate in preparation of Group Risk Assessment. – Conduct investigation of all near miss cases / Fatal / dangerous occurrences & recommend appropriate corrective measures. – Convene EHS Committee meeting & minute the proceedings for circulation & follow-up action. – Advice & co-ordinate for implementation of Work Permit Systems. – Plan procurement of PPE & safety devices and inspect before use as per laid down norms. – Report to Cluster EHS head on all matters pertaining to status of EHS and promotional program's at site level. – Facilitate screening of workmen and conduct EHS induction. – Monitor administration of First Aid. – Conduct Fire Drill, Procure, inspect and arrange to maintain Fire Extinguishers. – Organize campaigns, competitions & other special emphasis program's to promote EHS in the workplace. – Register Customer complaints and take corrective action. – Apprise Cluster EHS Head on EHS related problems. – Deploy Safety Steward suitably. – Notify site personnel if non-conformance to EHS norms observed during site visits/site inspections.



	– Recommend to Site In-charges, immediate discontinuance of work until rectification, of such situations warranting immediate action in view of imminent danger to life / property / environment. – Decline acceptance of such PPE / safety equipment that do not conform to specified requirements and report to Cluster EHS Head on the deficiencies identified during receiving inspection.
Safety steward	– Monitor Safety practices, persuade to minimize non compliance – Report incidents beyond control and unsafe occurrences to HSEO s
QMS coordinator	– Organize and conduct Management Review Meeting at regular intervals at site. – Co –ordinate internal & external audits
QA In charge	– PQP Preparation. – Training all site staff about the Quality requirements as per QMS – Identify and ensure development of methods, ITPs and all quality records. – Identify and develop Master List of Testing and Measuring Equipment - calibration – Ensure QA/ QC tests on materials and workmanship as per ITP – Coordinating for early disposal of non-conformity reports – Organizing and conducting Quality audits with the co-ordination of all concerned
QC Engineer	– Identify material sources, and conduct material tests and ensure conformity with specifications & standards – Conduct Routine Tests on materials & workmanship as per ITP for conformance and maintain records. – Identify, Calibrate and maintain Master List of Testing and Measuring Equipment. – Statistical analysis for product quality material (cube, plants, etc).
Accounts & Administration in-charge	– Fund Management. – Pay to suppliers and sub-contractors. – Collection of Customer outstanding. – Ensure adequate insurance coverage, timely claims and monitoring claim settlement in coordination with HQ.



	– Ensure conformance to statutory regulations and filing returns. – Responsible for Staff / labor welfare and general administration – Preparing & updating of cost statement – Activity wise cost booking – Ensure flow of proper PMS data into EIP and to Cluster/ HQ.
Accounts assistant	– Preparing & updating of all data related to accounts – Book keeping – Cash management – Banking operation for withdrawal & deposits and Reconciliation
Time officer	– Keep records of S/c workmen and departmental workmen. – Maintain in and out time of S/c and departmental workmen. – Preparation of daily labour report – Prepare bills and effect payment of departmental workmen – Maintain records pertaining to labour as per statutory requirements. – Responsible for labour welfare facilities
Stores officer	– Receipt & issue of materials including customer supplied material. – Arranging for inspection of incoming materials. – Proper storage of materials. – Ensure proper identification and traceability of materials – Ensure proper Stock analysis and inventory control / documentation

Note: the above responsibility matrix is only for guidance. The above matrix shall be modified based on Project specific requirement.

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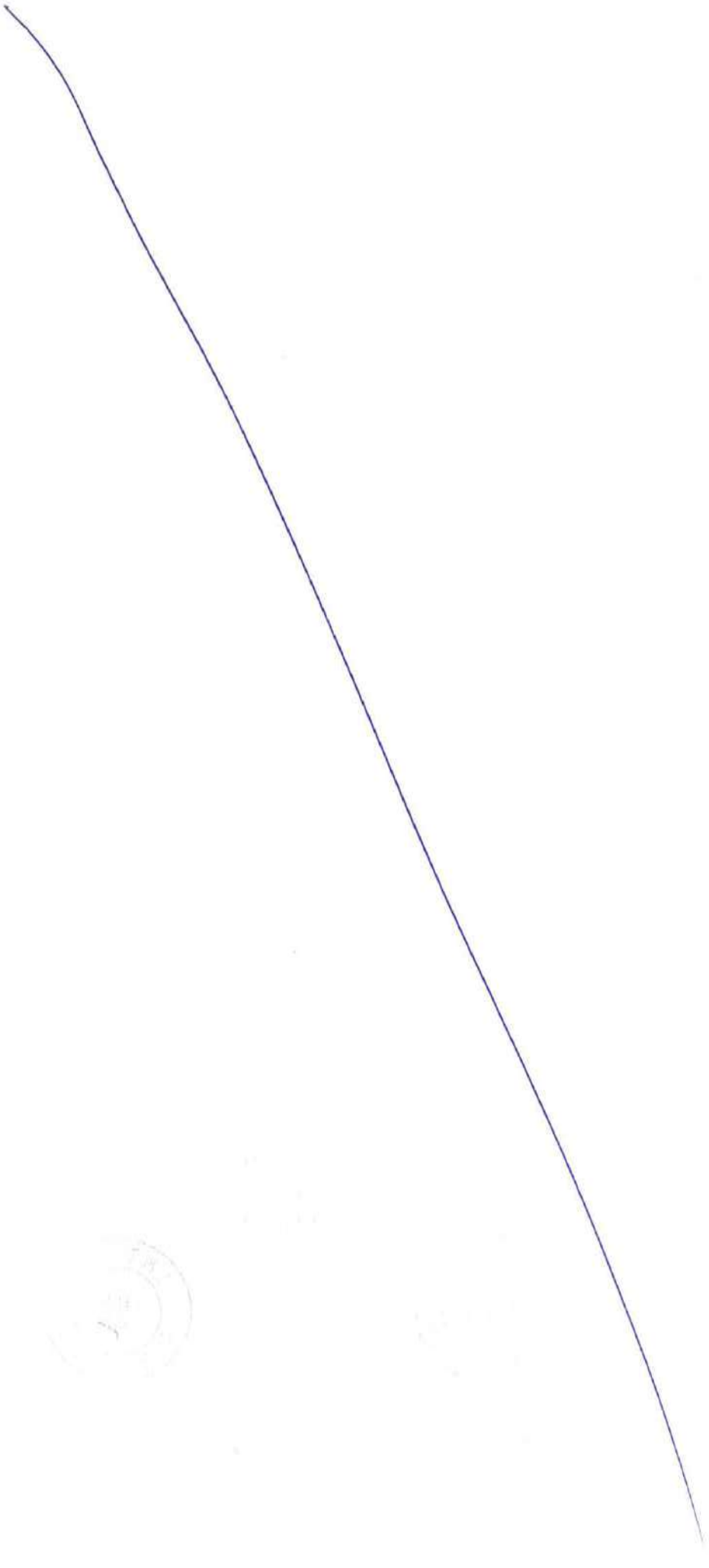


Quality Assurance Plan

Reference ISO Clauses: 5.1, 6.3, 7.1, 8.2, 8.5, 9.1, 9.3

1. **TITLE** : **Procedure for Management review**

2. **PURPOSE** : To assess and ensure effective implementation and continual improvement of the Quality Management System in satisfying the needs of customer and organization and taking necessary actions to close the gaps.

3. **SCOPE** : Quality Management System (Project Quality Plan)

4. **REFERENCE** : Procedure for: Quality objectives, Document control, Planning, Execution, Internal audits, Human resource & training, Corrective actions, Customer feedback, Risks & Opportunities.

5. **RESPONSIBILITY** : **PRIMARY:** QMS coordinator (SITE)

6. **PROCEDURE:**

6.1 Plan Management review meeting for the site at least once in three month interval. This can also be combined with the regular performance review meetings.

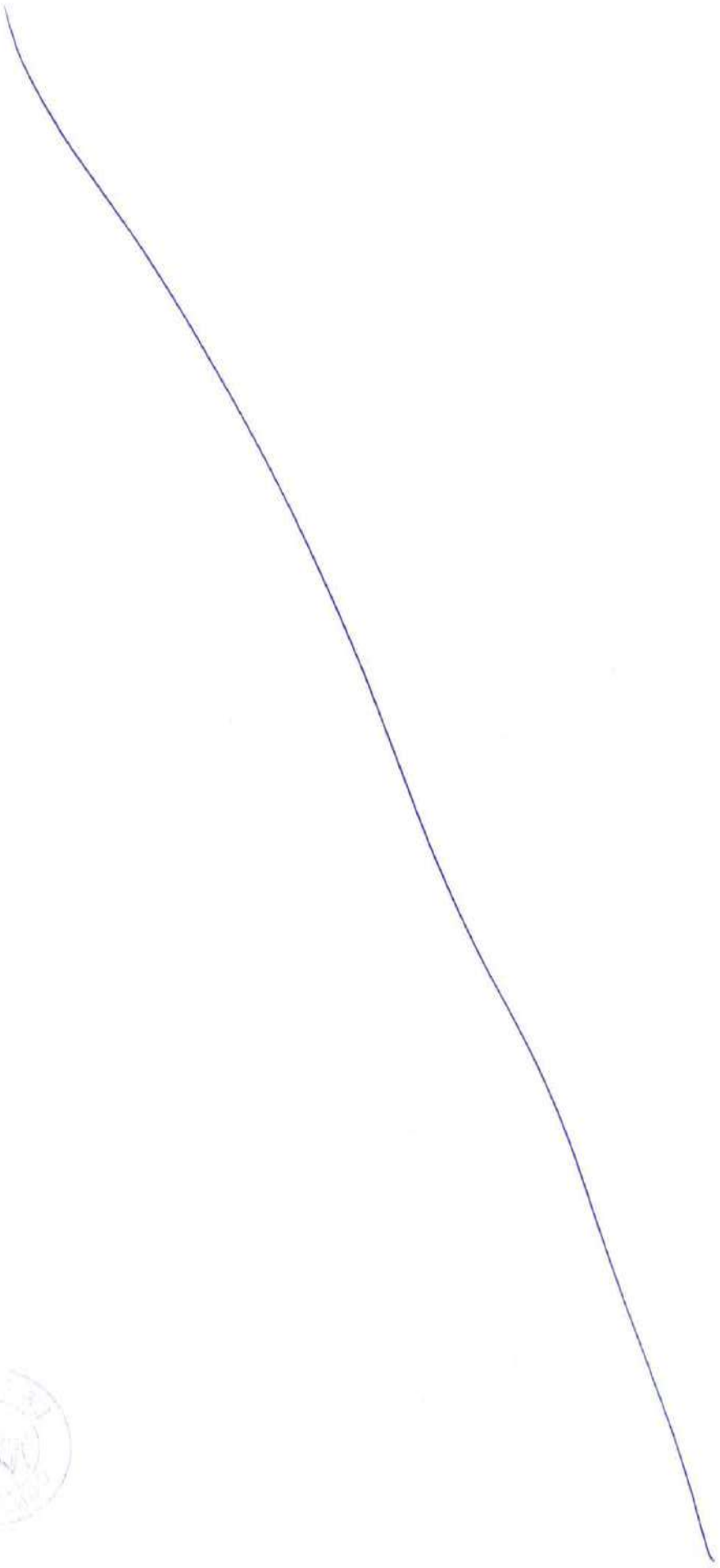
6.2 Send MRM notification with agenda well in advance to all attendees to enable them to come prepared for discussions.

6.3 Collect & compile the data as per the Agenda and present in MRM for discussions and decisions.

6.4 REVIEW INPUTS

Agenda for MRM shall be as follows:

(a) Pending points of Previous Meeting & review action plans implemented
(b) Changes in external and internal issues affecting QMS
(c) Progress on Quality Objectives
(d) Customer satisfaction & feedback
(e) Process performance & conformity of Product & services
(f) Result of Audits
(g) Corrective actions
(h) Performance of external providers
(i) Resources requirement (If any)
(j) Effectiveness of actions taken to address risk & opportunities



(k) Opportunities for Improvements in process, product, best practices

6.5 REVIEW OUTPUTS

Prepare Minutes of meeting in line with points discussed as per the agenda covering decisions on:

- Opportunities for Improvement
- Any need of changes in QMS (Project quality plan)
- Resource requirements

6.6 Send MRM Minutes with action plan, time schedule and responsibilities as decided in the review meeting to participant.

6.7 Follow up and action plan shall be implemented as decided in the review meeting as per time schedule and responsibilities.

7. RECORDS:

1. MOM of Management Review Meeting - WP 05 F 01

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Quality Assurance Plan

Reference ISO Clauses: 7.1, 7.2

1. **TITLE** : **Procedure for Human Resources & Training**

2. **PURPOSE** : To Plan, arrange resource (P&M, Materials, Subcontractors, Suppliers, staff, workmen), and train people individually and collectively for them to contribute their full expertise for achieving goals.

3. **SCOPE** : Quality Management System (Project Quality Plan)

4. **REFERENCE** : Procedure for:
   Quality objectives
   Management review
   Internal audits
   Customer feedback

5. **RESPONSIBILITY** : **PRIMARY** : Project in-charge
   SECONDARY: Section heads

6. **PROCEDURE:**

6.1 Plan for resources requirements for staff, P&M, materials, workmen & external providers to meet contractual requirements.

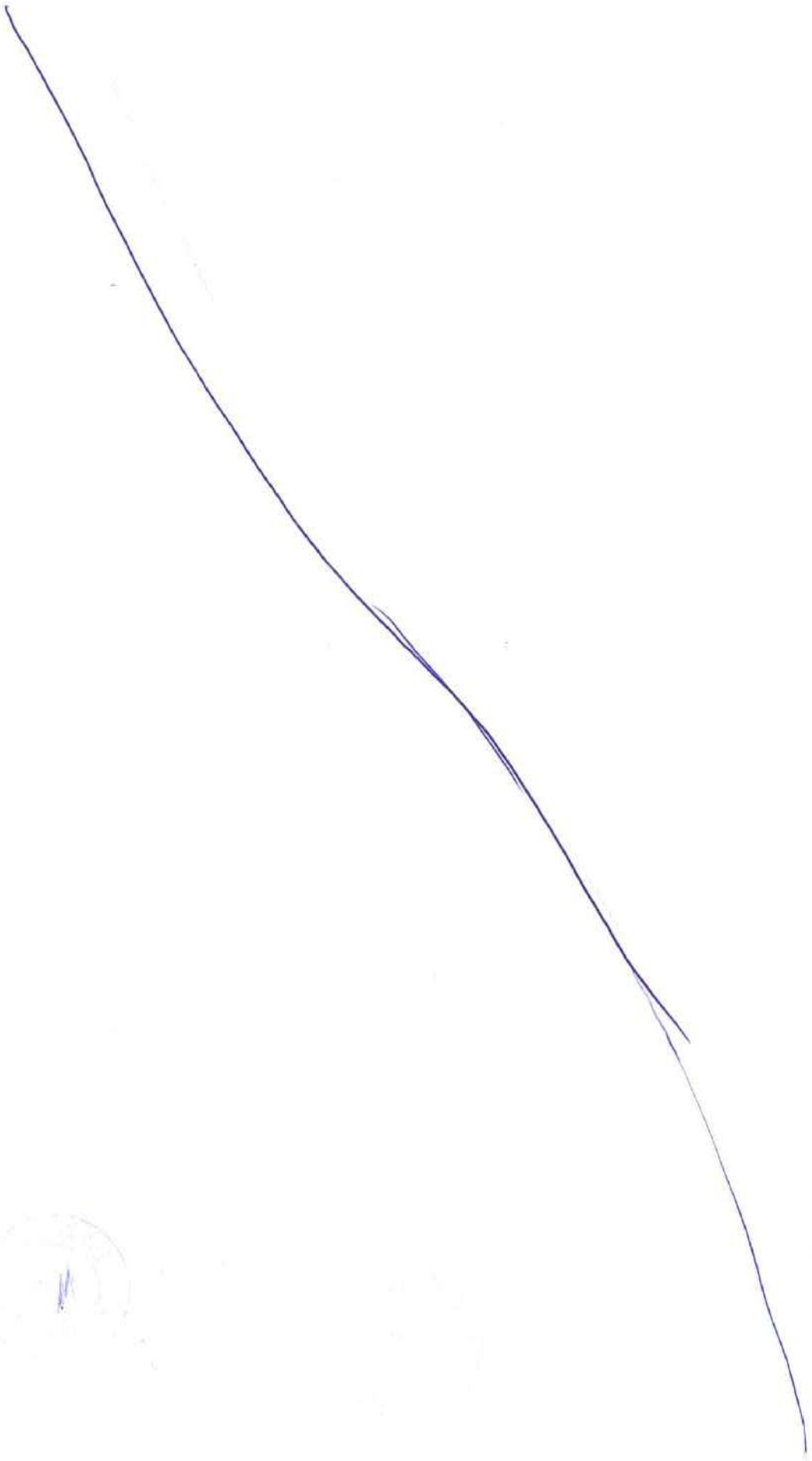
6.2 Obtain approval from the Cluster Head (CH).

6.3 Organize the resources as above from HQ/Cluster office/site with the help of CH.

6.4 Send revised schedules at monthly interval after assessing adequacy and effectiveness.

6.5 Identify the personnel required to perform the work affecting Quality of the product based on the following criteria

- Discipline
- Functional experience and skills.
- Competency



6.6 Training needs for Employees:

- Ensure QMS awareness for the project team.
- Identify training needs of employees, recommend for in-house / external / on job training.
- Update appraisal form and recommend to P&OD annually in FAIR form as per their training calendar.
- Evaluate and monitor the effectiveness of the training , as applicable by means of interactions on by any other means.
- Maintain the information relevant to trainings & competencies of people.

6.7 For Sub Contractors, supervisors & workmen:

Responsibility : **PRIMARY:** Section heads, QMS coordinator (Site)
SECONDARY: Project in-charge

- Plan / Identify training needs of contractors supervisors and workmen
- Conduct on job training and evaluate by interaction or by verifying the subsequent job executed.

7. RECORDS:

1. Details of trainings recommended (staff)
2. List of staff and their specializations (competencies)
3. List of trainings conducted along with attendance sheet (Workmen)

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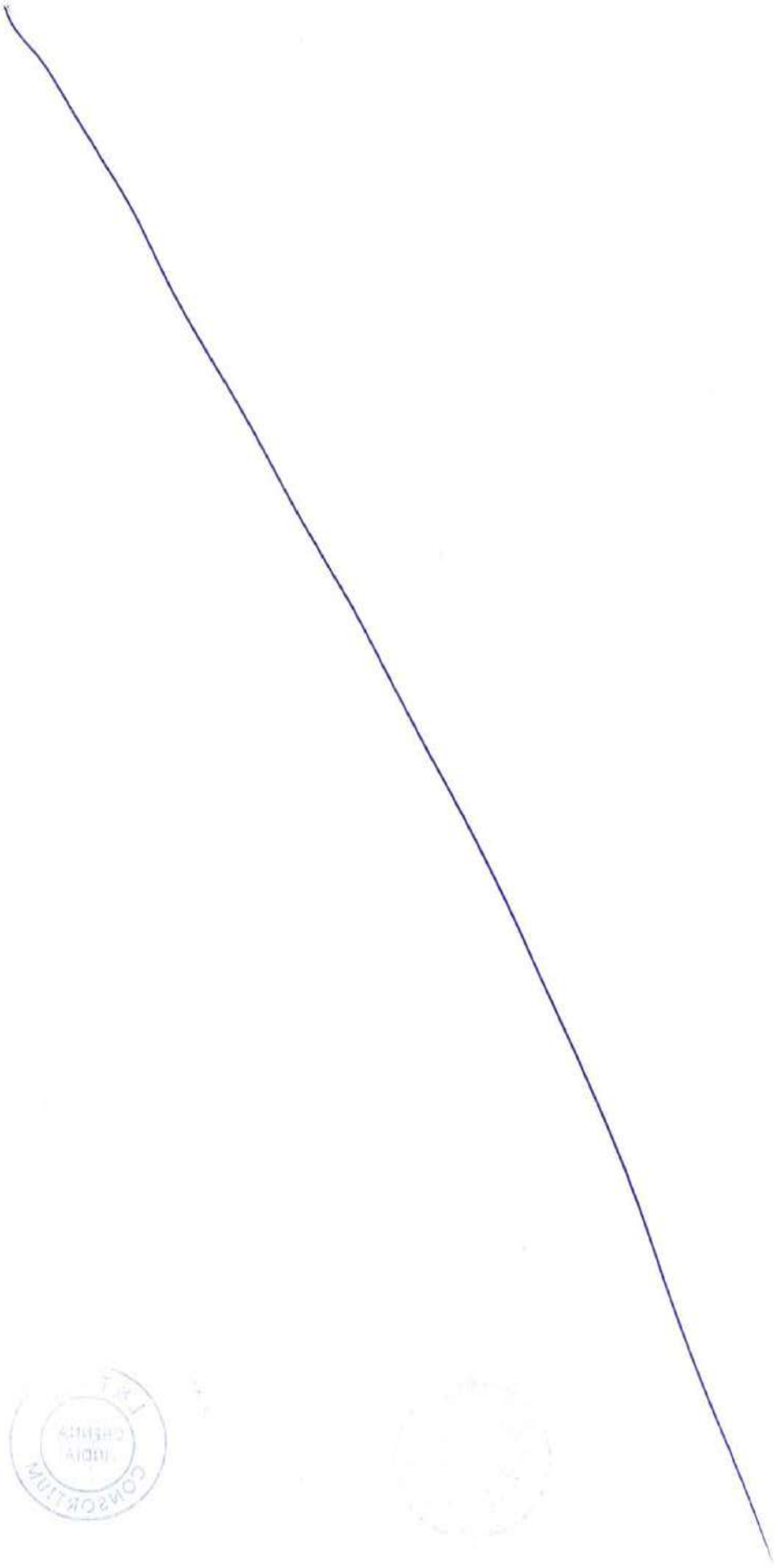

Quality Assurance Plan

Reference ISO Clauses: 7.1, 8.1, 9.1

1. **TITLE** : **PROCEDURE FOR PROJECT PLANNING AND MONITORING**

2. **Objective** : To Establish and maintain a procedure for project planning and Scheduling to achieve effective control of operation and construction activities.

3. **Scope** : Planning, monitoring and control of all activities of project as per contract from Mobilization to handing over of project.

4. **References** : **Procedure for:**
   Contracts management
   Execution of project
   Procurement
   Resources

5. **Responsibility** : **Primary:** Planning in-charge; **Secondary:** Project in-charge.

6. **Procedure:**

6.1 Receive the following contract documents from HQ (tendering department):

- Contract documents
- Customer correspondences
- Letter of intent (LOI)
- Minutes of Kick off meeting
- Others (if any)

6.2 Study the contract documents and understand the project requirements with respect to product, time and cost including other conditions as agreed in contract.

6.3 Prepare following planning schedules:

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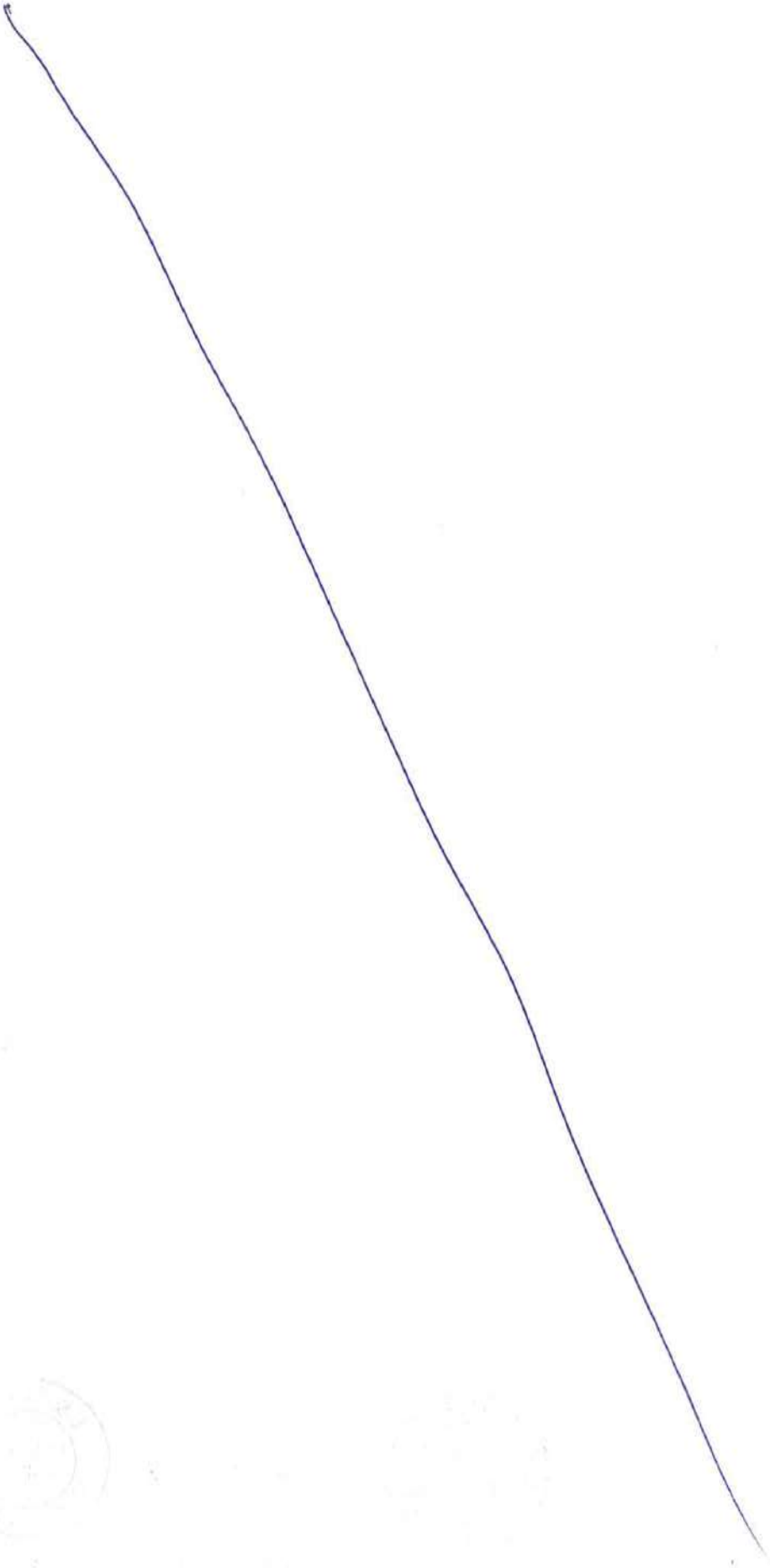
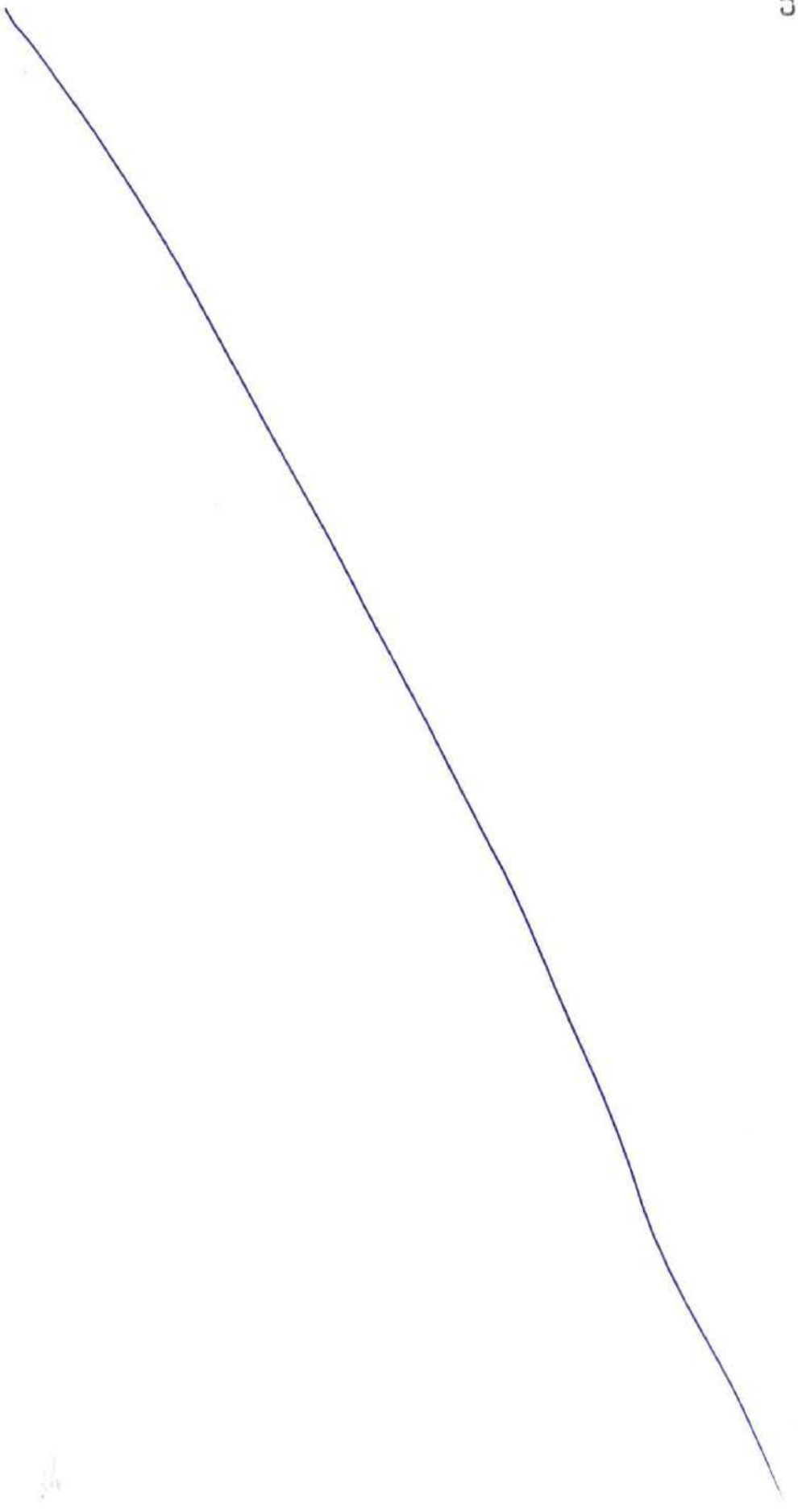


- Prepare, review and finalise Project Schedules / construction program based on the Contractual Requirement (Baseline /master program). Scheduling and Control Charts, CPM or PERT etc.
- Submit the same to customer /his representative and obtain approval.
- Prepare work break down structure in line with approved master program. Consult and coordinate with construction manager /section heads to implement the program.
- Prepare 3 months look-ahead program and issue it to construction manager /sections heads to prepare monthly, weekly and daily plans as applicable.
- Collect monthly program/ weekly program or program as per any other suitable frequency from construction manager / sections heads and compare with main program. Review the programs for effective implementation and monitoring
- Prepare resources (manpower, material and equipment) planning and arrange for the same.
- Prepare schedule of invoicing and submit to customer.
- Identify and list out the statutory & regulatory requirements to be complied with (as per Contract Document, Bye laws).
- Prepare monthly report and send it to customer (if required contractually).It shall cover the following but not limited to:
  - Updated schedule
  - Resources
  - Constraints
  - Material status
  - Drawing status
  - Safety statistics
  - Quality report
  - Delays & action plans.
  - Other highlights

6.4 Project monitoring:

- Receive progress reports weekly or any other suitable frequency from construction manager /section heads. Compile progress of all areas and

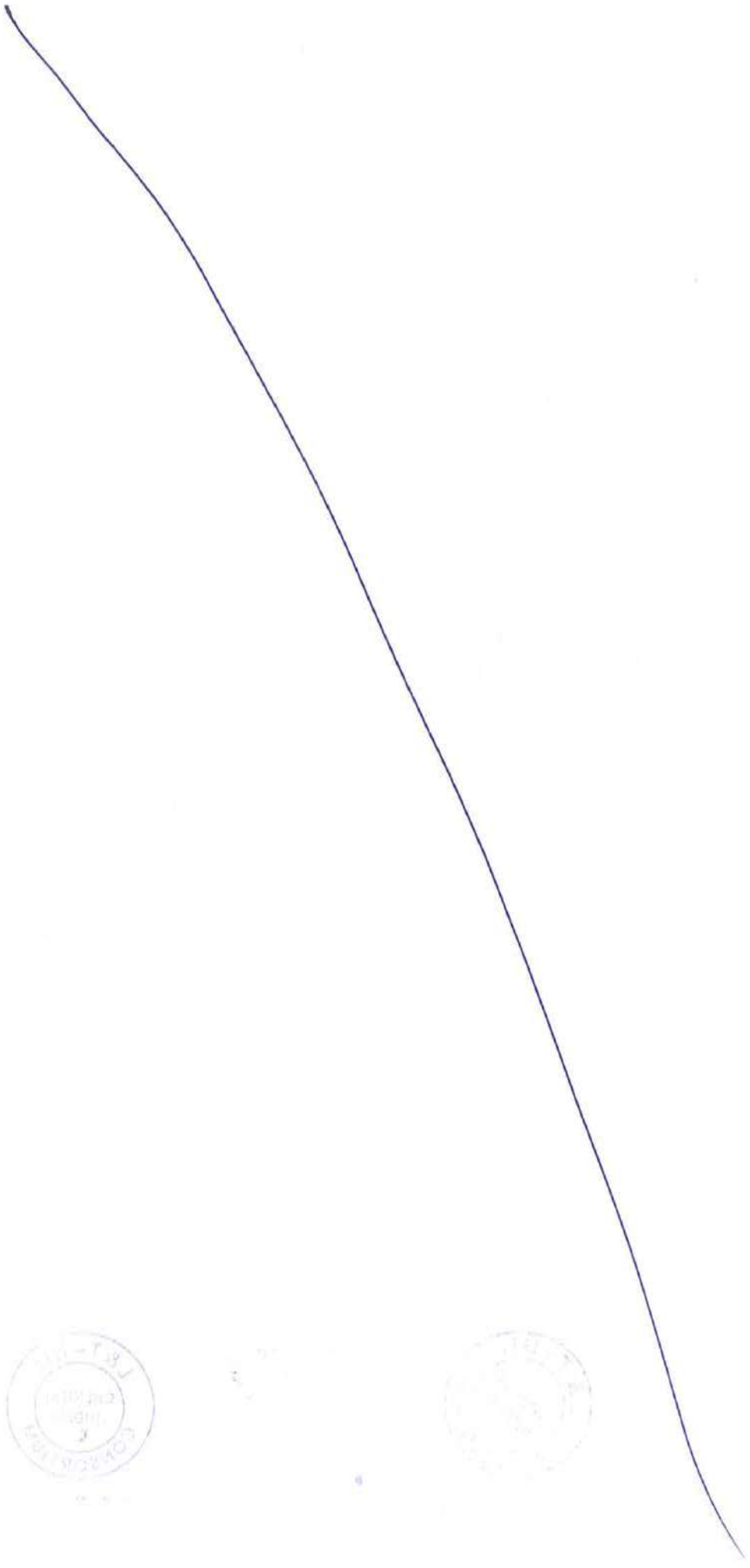


submit the same to customer (if required contractually) through project manager.

- Prepare monthly progress reports and submit the same customer and Cluster office / HQ through PM.
- Update 3 months look ahead programs. Analyze the gap with respect to plan, discuss with Project manager and respective construction manager/section heads. Prepare action plan to catch-up the delays.

7. **Records:**

1. LOI / Contract
2. MOM of Kick off meeting
3. Mobilization plan
4. Construction schedule / Program (master schedule)
5. Manpower planning
6. Material planning
7. Equipment planning
8. Invoice and fund planning
9. Periodical progress reports as per the suitable frequency.



L&T - IHI

Mumbai Trans Harbour Link Project (Package-1)

IFB No: MMRDA/ENG1/000752

Quality Assurance Plan

Reference ISO Clause: 8.2

1. **TITLE** : **PROCEDURE FOR CONTRACTS MANAGEMENT.**

2. **Objective** : To Establish and maintain a procedure for contracts management of the project to fulfill the agreed terms & conditions of contract.

3. **Scope** : All aspects of contract ,all contract letters to client(letters dealing with issues related to cost, quality ,time and safety)

4. **References** : **Procedure for:**
   Planning and Monitoring
   Execution of project
   Resources

5. **Responsibility** : **Primary:** Contracts in-charge;
   Secondary: PI, CM, Planning in-charge.

6. **Procedure:**

6.1 Receive the following contract documents from HQ (tendering dept):

i. Contract documents
ii. Customer correspondences
iii. Letter of intent (LOI)
iv. Minutes of Kick off meeting
v. Others (if any)

6.2 Study the contract documents and understand the project requirements with respect to product, time and cost including other conditions as agreed in contract.

6.3 For effective contract management:

- Prepare Schedule of submissions to the customer and target dates for the same.
- Identify and list out the statutory & regulatory requirements to be complied with (as per Contract Document, Bye laws).
- Prepare Risk mitigation plan and risk register.

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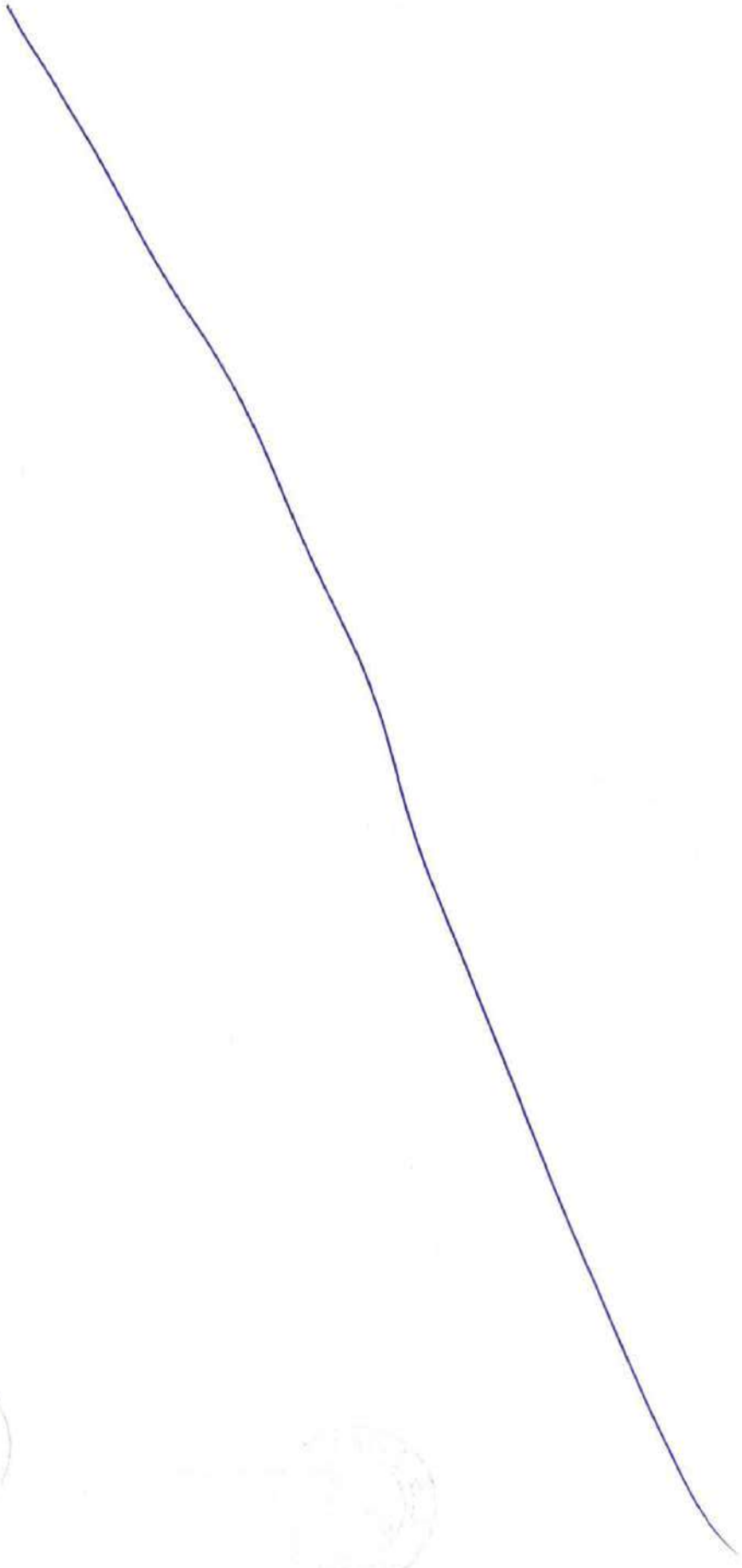

- Record obligations /variations (change orders) and agree with the client basis with necessary time & cost.
- Tracking of pending invoice to be raised, measurement and client's certification of invoice.
- Review of target milestone, invoicing to be made, and pending client certification.
- Work out escalations, currency variations/rate adjustments and inform client
- Identify the variations with reference to scope such as quantity, time, and cost (loss & expense). Notify and discuss with customer /his rep on time for early settlement.
- Escalate delays, deviations in terms of time/ milestones, scope, cost both to the customer & organization.
- Maintain all contractual correspondences and supporting documents for the project.
- Obtain project completion certificate from customer.
- Ensure planning and arrangement for defect liability period as per contract.
- Ensure timely project close-out in all respect as per the agreed action plan.
- Periodic reporting of cost incurred for projects under DLP, and its monitoring against original estimates.

6.4 Send status of disputes and Issues to HQ as required.

7. Records:

1. LOI
2. MOM of Kick off meeting
3. Schedule of submissions.
4. Statutory compliance check list (PQP/WP 08 F 01)
5. Milestone compliances
6. Project completion certificate
7. All customer correspondence
8. Change orders /variation orders
9. Risk register
10 Status of disputes and Issues

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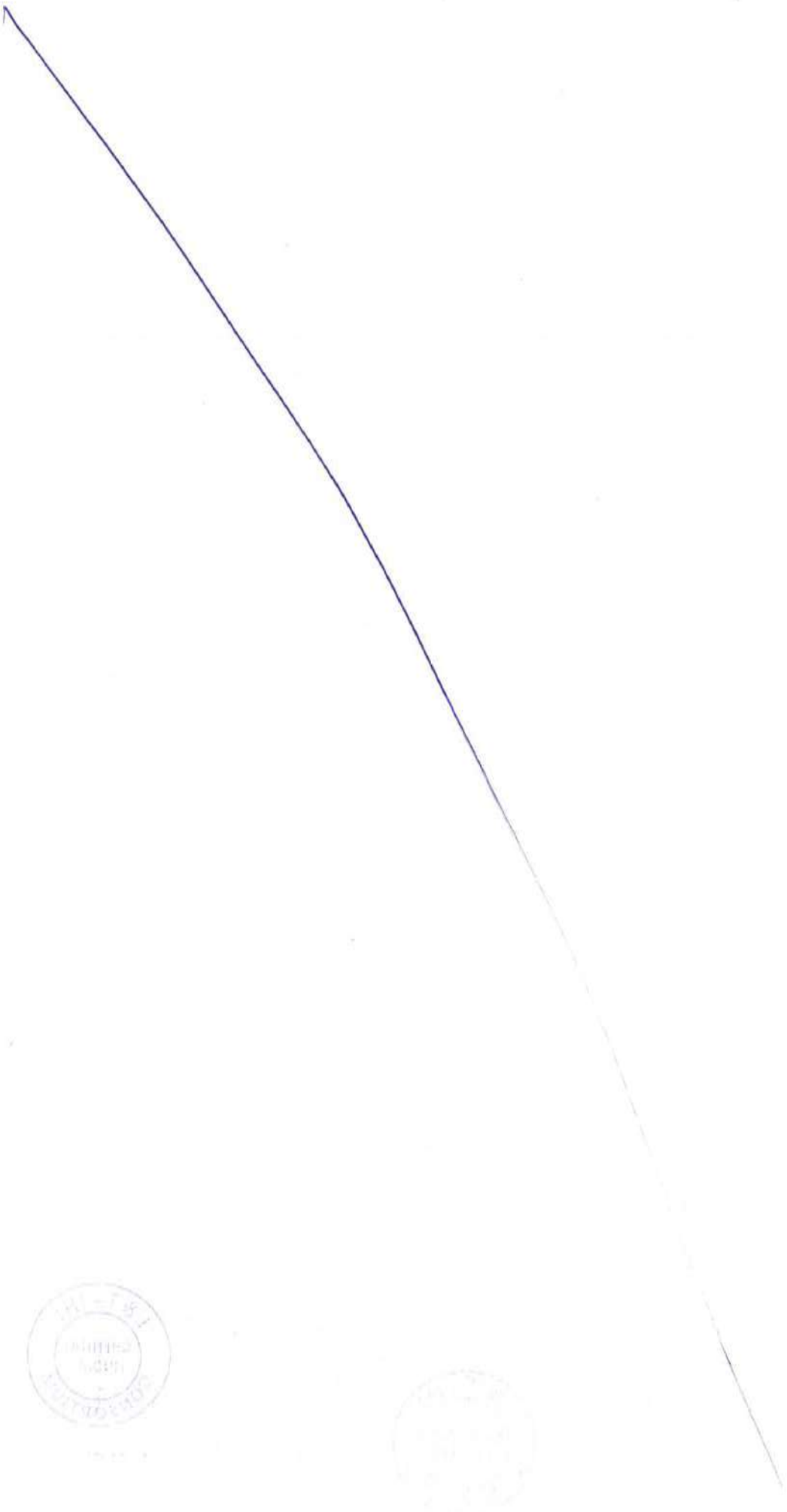

Quality Assurance Plan

Reference ISO Clauses: 8.1, 9.1

1. **TITLE : PROCEDURE FOR MOBILISATION, REVIEW & MONITORING OF PROJECT**

2. **Objective** : To Establish and maintain a procedure for mobilization, review and monitoring of project to support, optimum utilization of resources and timely completion.

3. **Scope** : Resources mobilization, monitoring and completion of project. Implementation of EIP and achieving financial parameters.

4. **References** : **Procedure for**
   - Contracts management
   - Execution of project
   - Procurement
   - Resources
   - EIP system,
   - Risk management

5. **Responsibility** : **Primary:** Project In-charge;
   Secondary: Site Accounts in-charge, Planning in charge, Contracts manager, Construction manager.

6. **Procedure:**

6.1 Receive the following contract documents from HQ (tendering dept):
- Letter of intent (LOI)
- Contract documents
- Customer correspondences
- Minutes of Kick off meeting
- Others (if any)

6.2 Study the contract documents and understand the project requirements with respect to product, time and cost including other conditions as agreed in contract.

6.3 Prepare and implement of following:

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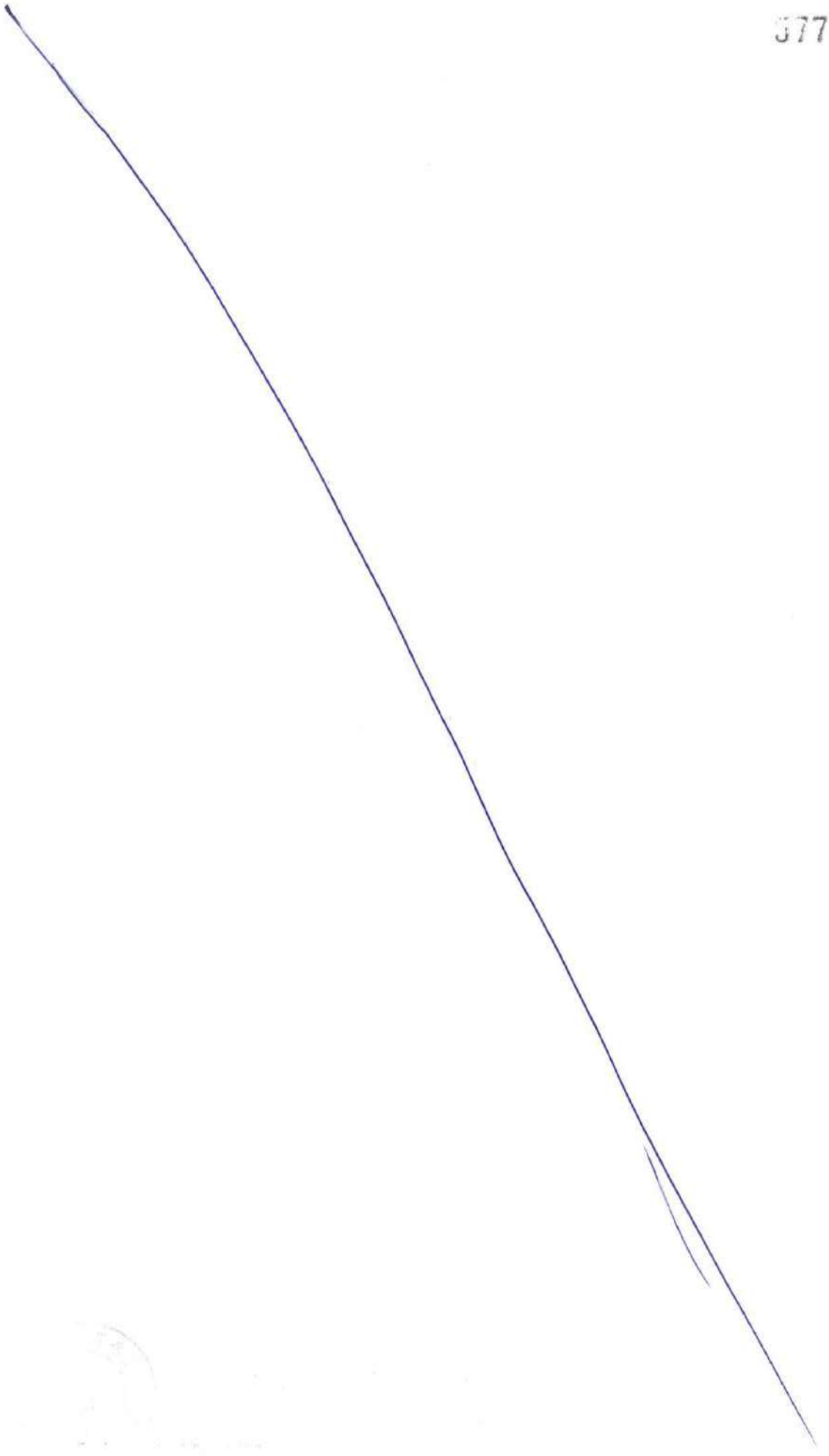


- Management Planning and Control Schedules (S0,S3,S4 etc). S0 – Schedule of Construction program based on the Contractual Requirement.
- Accepted cost estimate (ACE)
- Quality objectives for the project
- Risk assessment plan including measures for mitigating the same
- Identify and list out the statutory & regulatory requirements to be complied with (as per Contract Document, Bye laws).
- Subcontractors Evaluation/selection/finalization as applicable.
- Subcontractor Work orders
- Purchase Request / orders as applicable
- Sub-contractor/ Vendor bills certification for payment
- Project completion report

6.4 Coordinate with Cluster office / HQ for resources (Selection of Vendor/Subcontractor for specialized items of work, P&M, Manpower and other if any). Arrange the same either locally or through cluster office / HQ as per the decision.

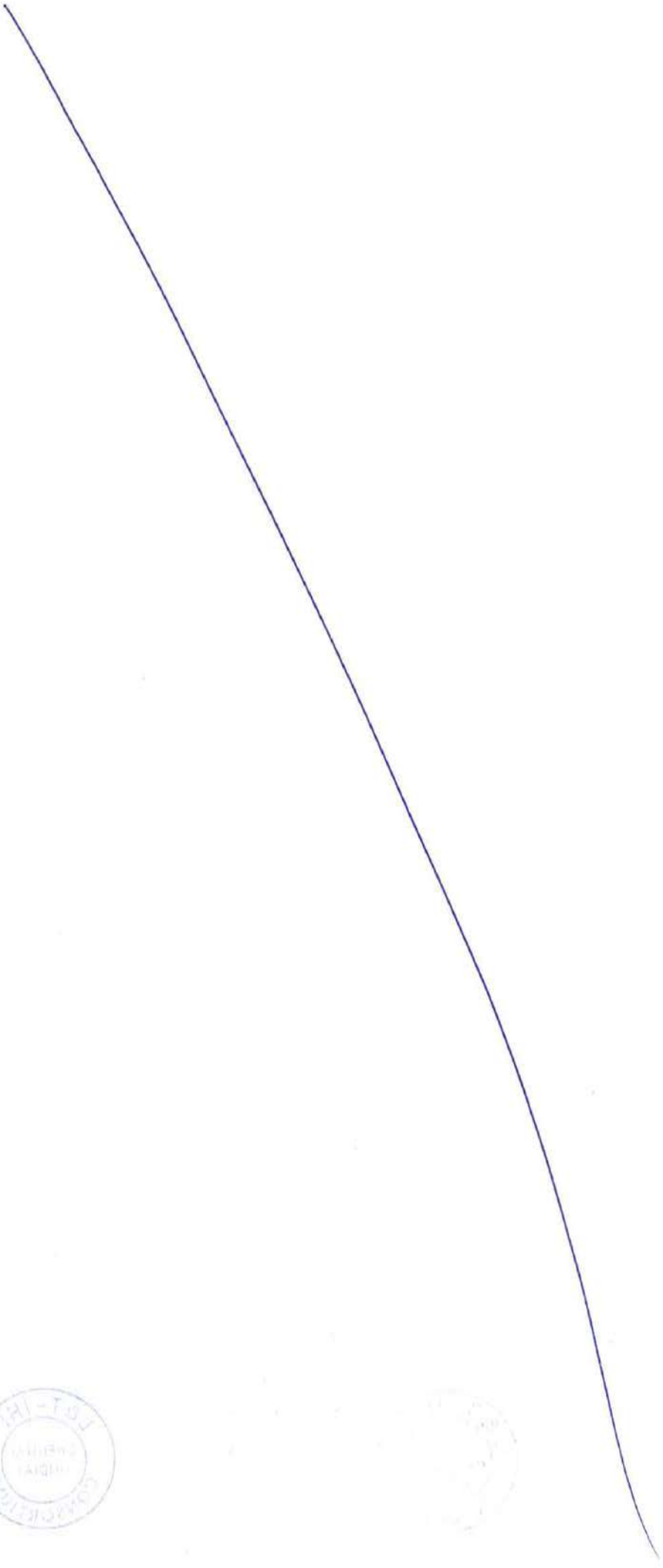
Project monitoring:

- Identify applicable and essential reports.
- Implement the identified system / reports consistently.
- Receive review comments from Cluster Head / HQ and discuss for improvements.
- Prepare project completion report and send to HQ.

8. Records:

- Prepare and send the following applicable schedules & reports as per the target /frequency.

Sl no	Description of report	Responsibility for preparation	Responsibility for Review	Target/ Frequency	Record
1	Accepted Cost Estimate (ACE)	Project Incharge	CH /BUH	Within one month of zero date	Approved ACE
2	Project Quality Plan(PQP)	QMS coordinator ,Section Heads	PI ,HQ-Quality department	Within one month of	PQP

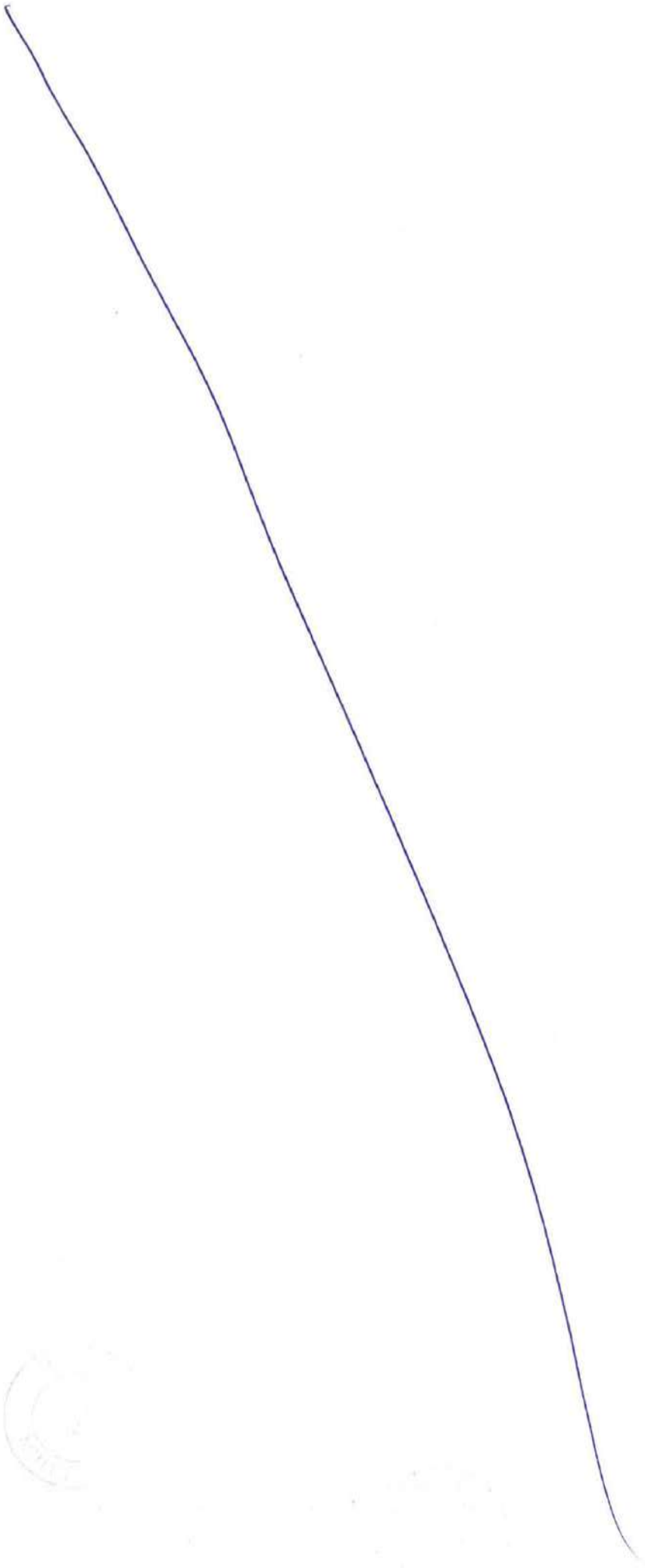


				zero date	
3	JCR for the month	PE	PI	Monthly	EIP
4	Monthly Quality Report	QA/QC in-charge	PI	Monthly	WP 09 F 01
5	Customer's Invoice vs. Certification	PE	PI	Monthly	Report
6	Reconciliation of Client's issue materials	PE	PI	Bimonthly	Report
7	Quantity Paid to S/c vs. customer	PE	PI	Monthly	Report
8	Cost Statement with Revenue Register	Site Accountant	PI	Monthly	EIP
9	Monthly Quarry & Crusher Production Reports	Q&C in-charge	PI	Monthly	MIS 01 F 01(Q&C)
10	Inspection records for activities	Section in-charges	QC	At the end of each activity	Reports/formats as indicated in procedures

Note : All other mandatory reports pertaining to MIS MPCS & SCR shall be maintained in EIP /Hard copy as per the management guidelines issued time to time.

9. Abbreviations:

1. CH : Cluster Head
2. PI : Project In-Charge
3. PI : Planning Engineer
4. HQ : Head Quarters
5. EIP : Enterprise Information Portal
6. PE : Planning Engineer
7. Q&C : Quarry & Crusher
8. KM : Knowledge Management



Quality Assurance Plan

Reference ISO Clause: 8.4

1. TITLE : Procedure for selection of Vendors, Subcontractors & Procurement

2. PURPOSE: Establish procedure for assessment and selection of vendors & subcontractors to procure material/ service.

3. SCOPE: Materials/equipment/services/subcontracts for project.

4. REFERENCE : Procedure for:

- Planning
- Contracts management
- Handling, storage & Preservation & control of materials
- Contract spec and approved drawings and Safety Manual

5. PROCEDURE:

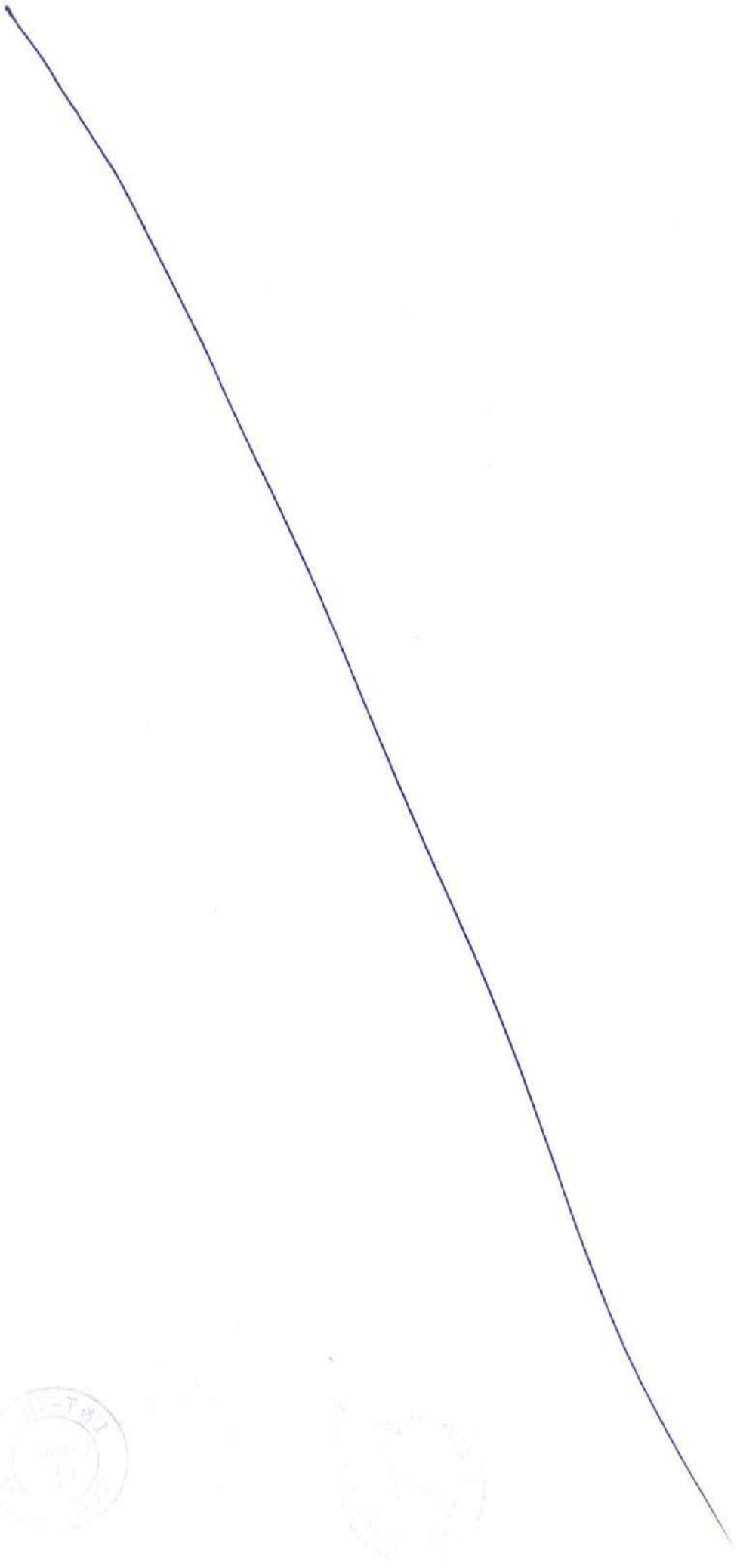
5.1 General

- All materials required for the project shall be procured from approved vendors / Sources only.
- All vendors shall be assessed based on their ability to supply materials which meets project requirements and other commercial terms and conditions. Details and status of approved vendors are maintained in EIP by materials dept.
- In case of emergency, materials are also purchased from unapproved vendors / sources subject to approval from competent authority for site purchase and for HQ / Cluster purchase as per the procedures of Materials dept.
- Based on Schedule of Material Requirement (S6) which clearly defines the total quantity, month-wise break up, source and procurement agency. Respective person initiates purchase activities as identified.

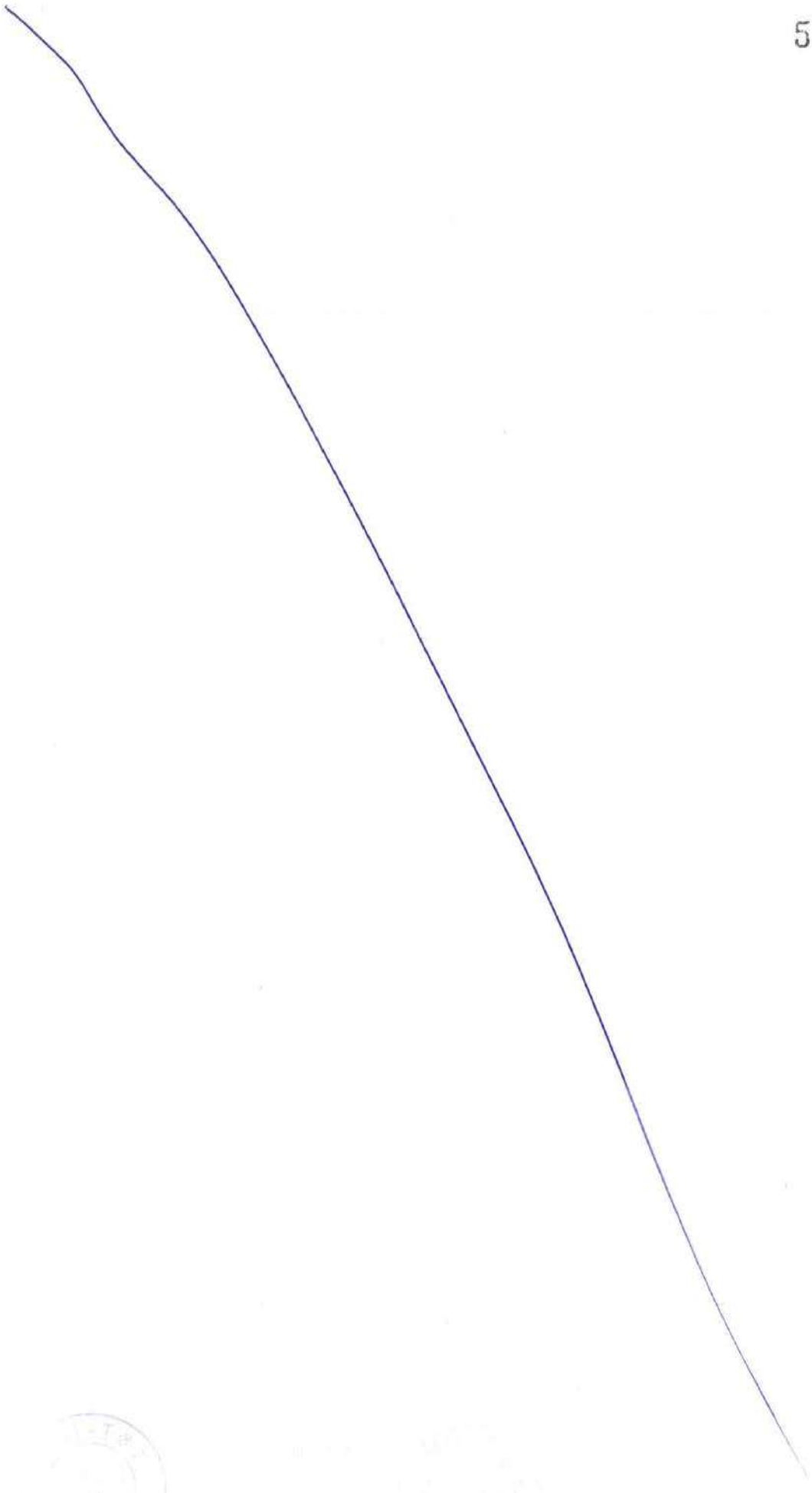
5.2 Supply Items procured from HQ/ Cluster office

Responsibility: Planning In-charge, Project In-charge

1) Receive Kick off meeting minutes on procurement strategy on items to be procured from HQ, Cluster office and site.



2) Send detailed Project program indicating delivery schedules to HQ / Cluster office.
3) Make 3 month rolling plan & next 3-month expected requirements (in line with project program) for Bulk Materials (Steel & Cement, etc.,)
4) Send the same to Cluster office / HQ, so that the procurement can be planned for all sites together.
5) Receive data sheet / brochures from HQ / Cluster office and submit to customer for approval if required contractually.
6) Inform customer approval status to HQ / cluster office if any.
7) The initial RFQ's are floated to the approved vendors as listed in contract document.
8) Vendors not listed in approved vendor list, but capable of executing the supply, are evaluated by L&T-IHI Consortium. RFQ's are floated these vendors ,
9) Up on receiving the technical offer from vendor, complete in all manners with respect to RFQ, the same shall be reviewed by design team and queries are raised in case clarifications are needed
10) Any deviations from suppliers which need customer concurrence shall be addressed Customer in approved DCR format by design team
11) On receipt of the technical compliance sheet, the selected vendors are called for commercial negotiation by procurement team and PO's are released after concurrence from ITER-India.
12) On acceptance of PO by the vendor, the list of documents namely QAP, datasheets, drawings (if applicable) and procedures as needed are submitted by the vendor for approval.
13) These documents are forwarded to the customer for approval.
14) After the approval of QAP, vendor shall initiate the supply of item/Manufacturing as per QAP and final clearance shall be obtained from L&T-IHI Consortium & Customer before dispatched.
15) During the process vendor shall be audited by L&T-IHI Consortium based on the importance & duration of supply.
16) Based on schedule prepare Material Request (MR) and send the same to concerned for approval.



17) Receive PO (Duplicate copy) and check the adequacies, delivery status dates and inform deviations if any to HQ / Cluster office for action.

18) Follow-up with purchase department in case of delay. Receive materials and check inspection report, Material Test Certificate (MTC) and Physical condition of materials and inform concerned personnel of the deviations / damages if any.

19) Follow corrective action if needed

5.3 Construction Materials procured from HQ / Cluster office

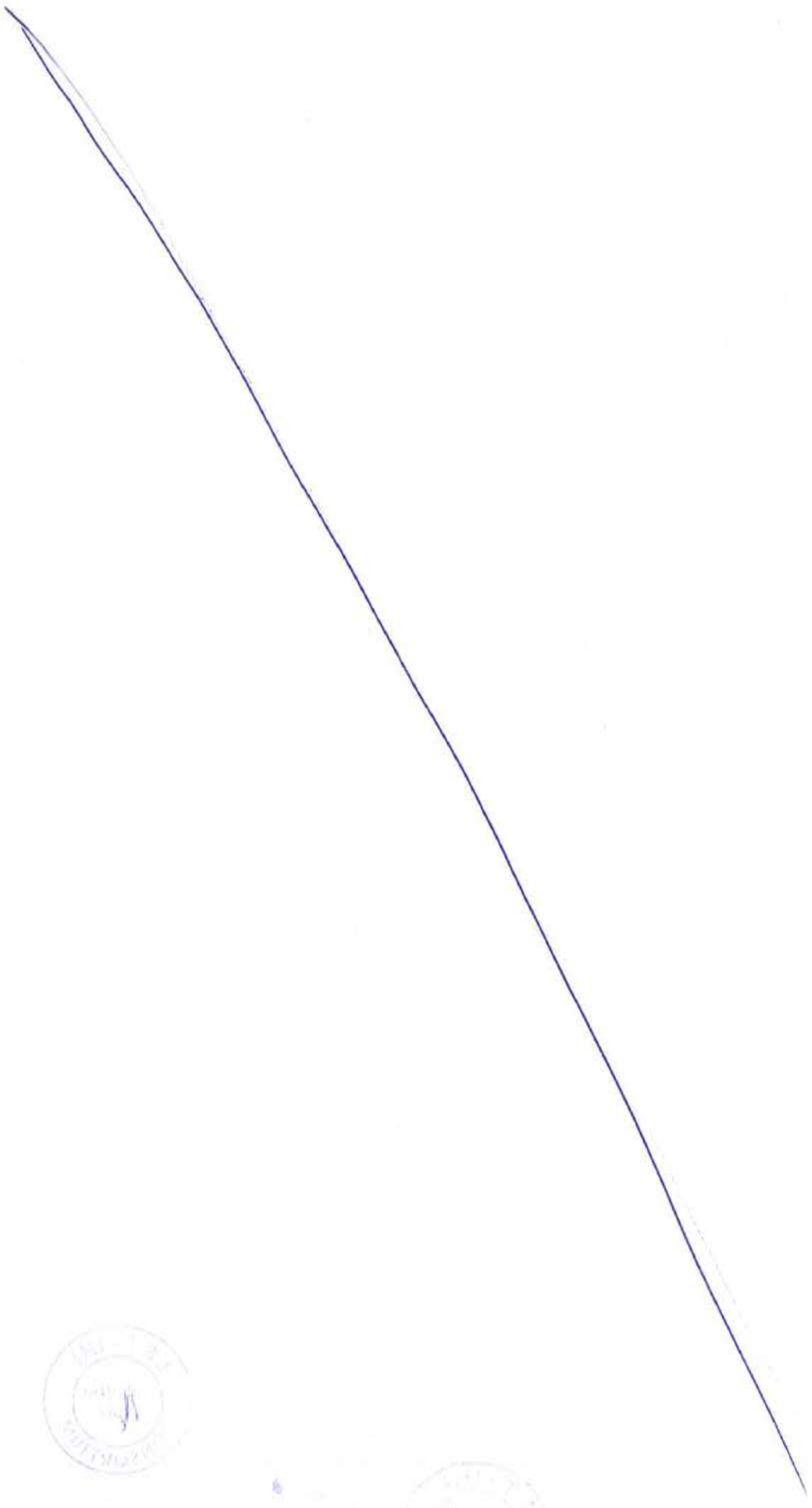
Responsibility: Planning In-charge, Purchase in-charge

1) Follow step 5.2 - 1
2) Send S6 with ACE provisions and list of approved vendors (contractually agreed) to Purchase department for HQ / Cluster office procurement
3) Raise Purchase requisition(PR) for materials indicating approved vendors agreed in contract, Specification of the product, inspection and acceptance criteria, delivery schedule and requirements of QMS.
4) Purchase in charge / Planning In-charge shall collect Quotations from approved vendors by giving details as per PR.
5) Prepare the Comparative statement and recommend the prospective suppliers, PI/PE/Purchase in charge shall negotiate with suppliers and finalises the suppliers one or more considering material schedule and quantity.
6) Purchase in charge shall then forward to Materials Dept. through Cluster Head for purchase (as per approved limits)
7) Purchase in charge shall follow-up with purchase department in case of delay.
8) Purchase in charge shall receive materials and offer the Materials & TC for inspection to designated persons & get MRN approved after inspection

5.4 Construction Materials procured from Site

Responsibility: Planning In-charge, Purchase in -charge

1) Follow step 5.1 -1
2) Raise Material request indicating specifications
3) Approve MR and send to Stores



4) Identify vendors for material procurement based on source of supply and capability of supply.
5) Prepare comparative statement and select capable vendor
6) Take rate approval from Cluster Head for material procured from site
7) Purchase in-charge shall raise PO on the approved vendors with detailed specification of the product, quantity, inspection and acceptance criteria, delivery schedule and requirement of QMS and send to PI for approval
8) Approve PO and send to Stores for procurement with a copy to indenter
9) Purchase in-charge shall arrange to get the Quality of material Checked at Vendors premises or on receipt at site (Material incorporated in Product) by designated person & approve MRN.
10) Accept approved materials or Follow procedure for Control of non-conforming product

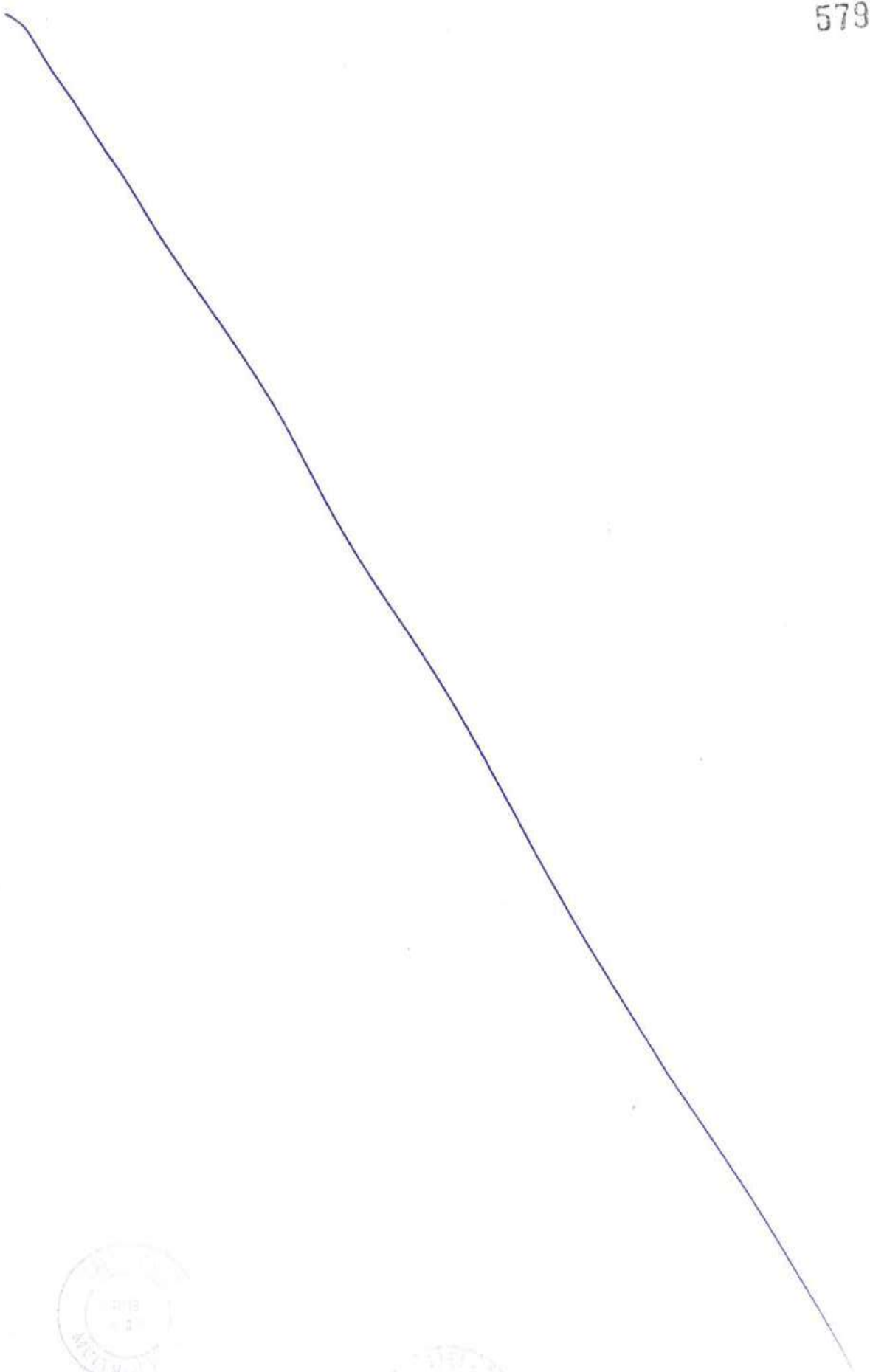
5.5 SERVICES / SUB-CONTRACTS

Responsibility: Project in-charge

1) Receive Kick off meting minutes on strategy on subcontracting to be initiated by HQ and Cluster office and site.
2) Obtain item rate approval from Cluster Head (where required).
3) Identify potential agencies based on previous performance and assessment.
4) Screen the Sub-contractors based on Technical / Financial competence
5) Obtain Quotes from selected parties and Negotiate
6) Place order on the party offering best technical and commercial terms after obtaining approval from appropriate authority
7) Evaluate the Sub Contractors / Specialised contractor periodically in EIP. (tentatively every quarter) – Annexure : PQP WP 10 GL 01
8) Update master list of Specialised contractors / sub-contractors in EIP

6. RECORDS:

1. All records as per stores manual in Portal
2. Quality Plan/ITP
3. Technical specifications



4. Screening of subcontractors as per EIP
5. Master list of specialized contractors as per EIP
6. Performance report as per EIP.

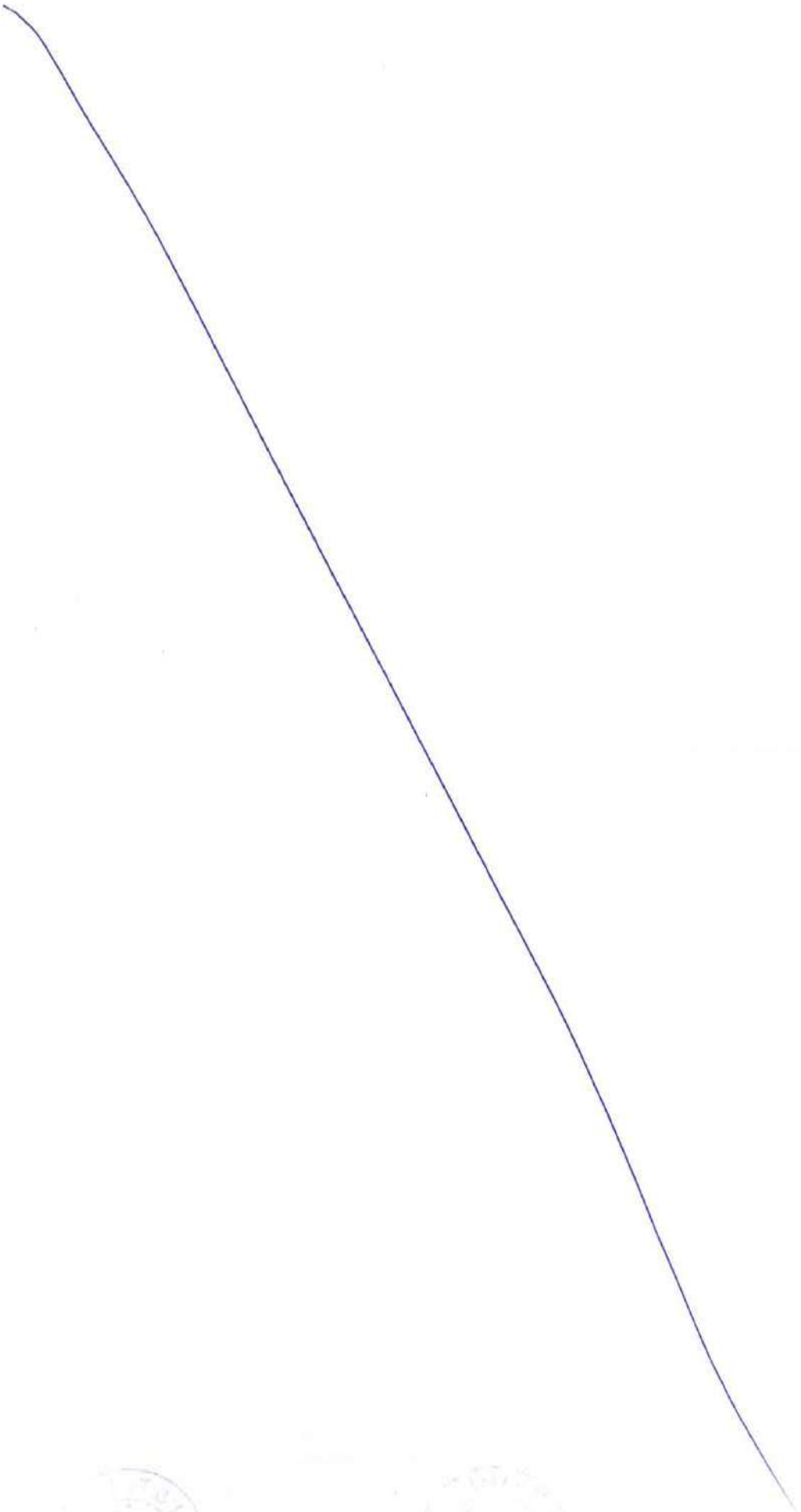
VENDOR QUESTIONNAIRE – SELF ASSESSMENT FORM

QUESTIONNAIRE FOR VENDOR /SUB-CONTRACTOR/MANUFACTURER

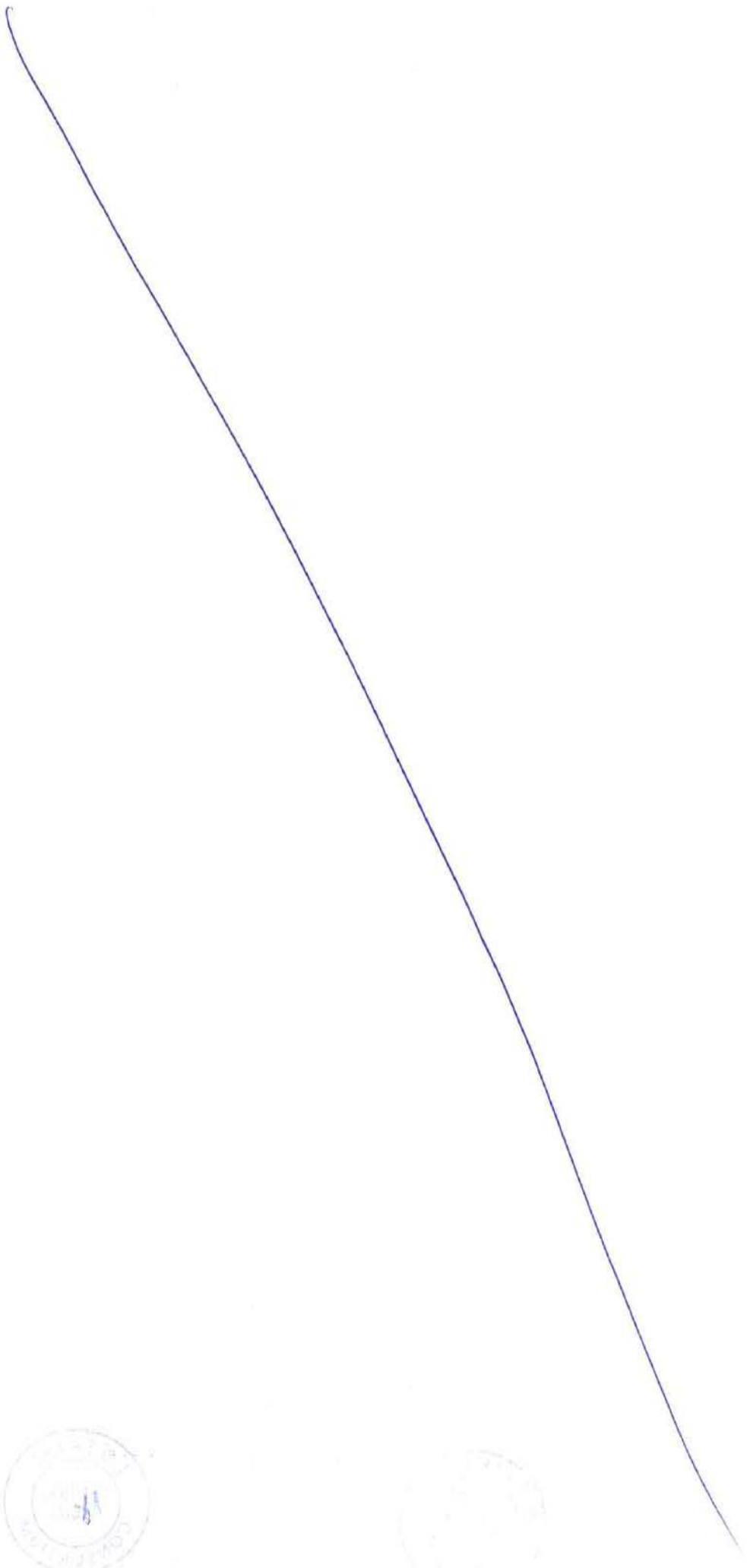
INSTRUCTIONS TO THE VENDOR/SUPPLIER FOR FILLING UP THE QUESTIONNAIRE

1. **The Vendor / Supplier is required to respond to all the questions given in this questionnaire. (Incase of ISO Company Certificate of Approval is required).**
2. **The reply to each question should be 'SPECIFIC' to the present condition of operation / systems followed.**
3. **The space provided against each question shall be used for giving replies. Where space is not found sufficient, a separate sheet for replies shall be enclosed. However care should be taken to co-relate the replies with the question.**
4. **If certain questions are found to be not applicable with respect to the present system followed, the reply shall be 'NOT APPLICABLE'.**

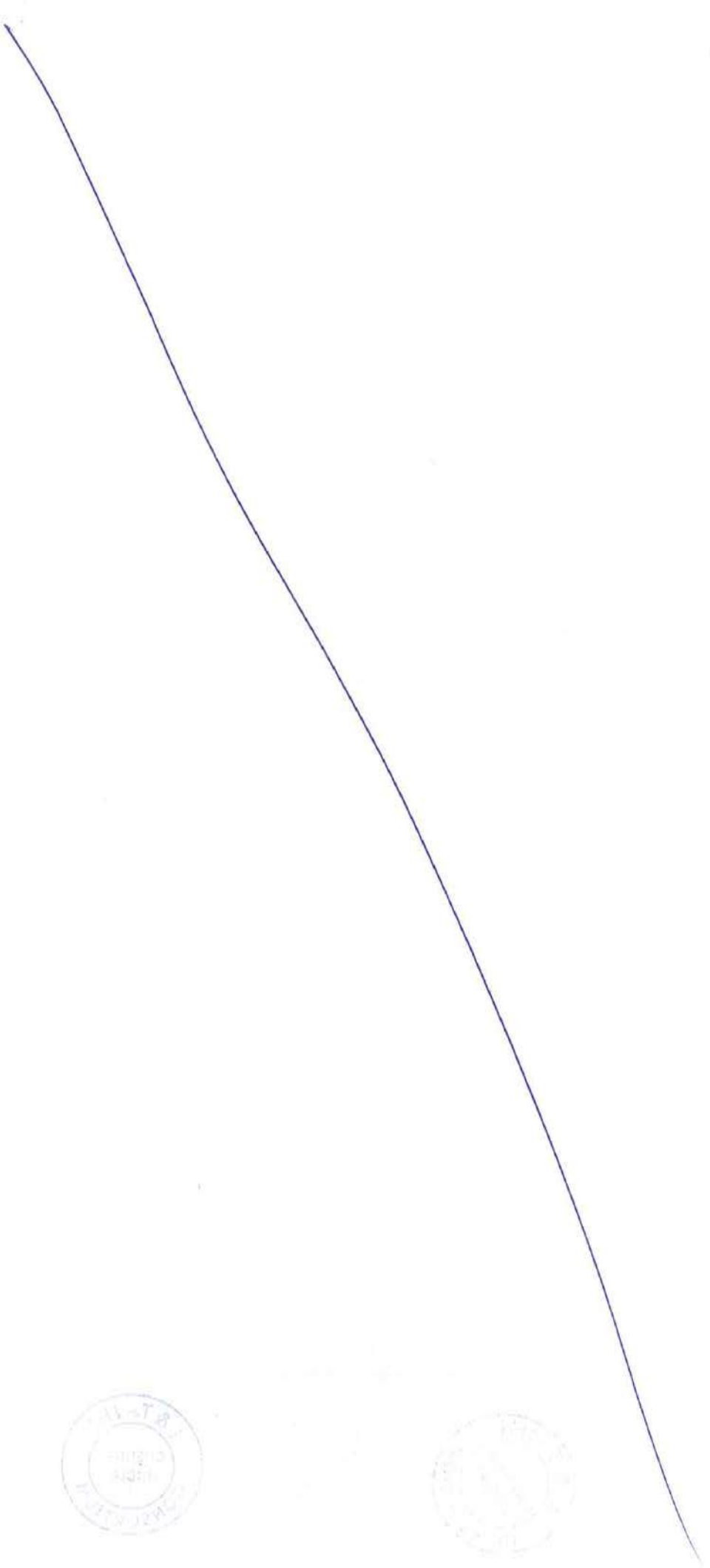
1.	Name of the Company	**Details**	
2.	a. Postal Address with Telephone nos.		
	b. Factory address with Telephone nos.		



3.	Head of the Company with Designation & Telephone no.		
4.	Constitution of the Company:		
	Sole Proprietorship/ Partnership/ Private/ Private Ltd. / Deemed Ltd./ Public Sector Undertaking		
5.	Nature of Business: Manufacturer / Vendor / Contractor / Fabricator		
6.	Registrations (Furnish details): Local Sales Tax, Central Sales Tax & Excise:		
7.	Area, Office, Factory, Total & Covered:		
8.	Are the land and building owned:		
9.	Details of bank facilities being availed & bankers:		
10.	The turnover in the last three years: (indicate separately)		
11.	Type and range of products being manufactured / handled:		
12.	Specify the product for which the acceptance is sought:		
13.	Give details if facilities for designing the product exist:		
14.	Indicate sources of raw materials:		
15.	Manufacturing facilities and material handling equipment: (if required attach separate sheet giving list of machineries with capacity &		

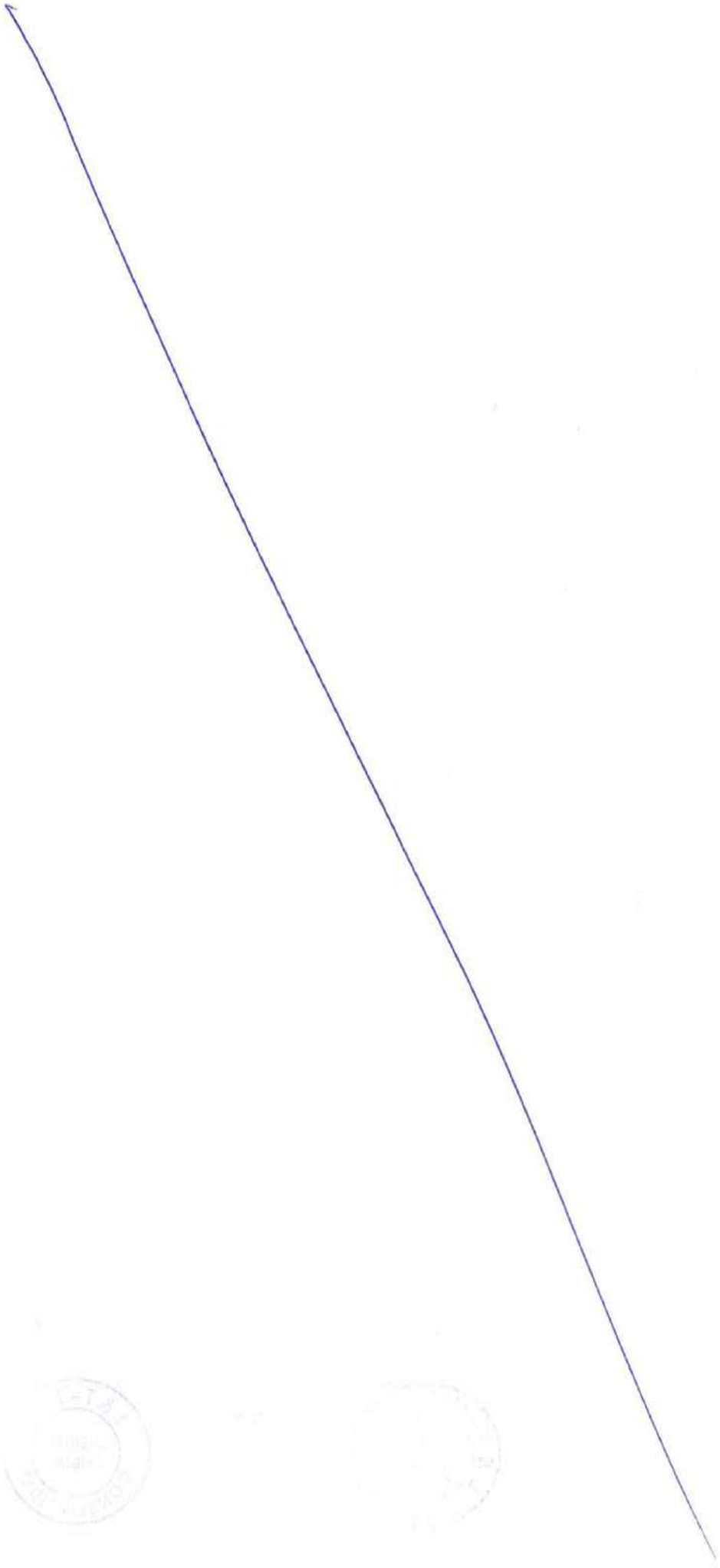


	quantity) At factory & at proposed project	
16.	Details of work force (Furnish details about No. of Managers, Engineers, supervisors, workers, skilled, semiskilled, others) involved: At factory & at proposed project: (Organizational chart shall be submitted)	
17.	Production capacity / month in terms of: At factory & at proposed project:	
18.	List of reputed customers:	
19.	Does the company have a production independent Quality control set up? If so whom does the QA / QC in charge report to:	
20.	Details of measuring instruments available in house with range & quantity.	
21.	Furnish details of testing equipment available in house with capacity and quantity:	
22.	Are instruments and test equipment calibrated:	
23.	Quality Assurance Plan /	



Quality Assurance Plan

	Inspection test Plan for products: (Attach a copy of format for reference)		
24.	System for Inspection of incoming materials: (Attach a copy of format being used to record the inspections)		
25.	Have you been approved by any of the Inspection Agencies / Consultants / Public Sector undertakings? If yes, provide details.		
26.	Any other details you wish to furnish to substantiate your credentials:		
1.	Name of the Company	**Details**	
2.	a. Postal Address with Telephone nos.		
	b. Factory address with Telephone nos.		
3.	Head of the Company with Designation & Telephone no.		
4.	Constitution of the Company:		
	Sole Proprietorship/ Partnership/ Private/ Private Ltd. / Deemed Ltd./ Public		

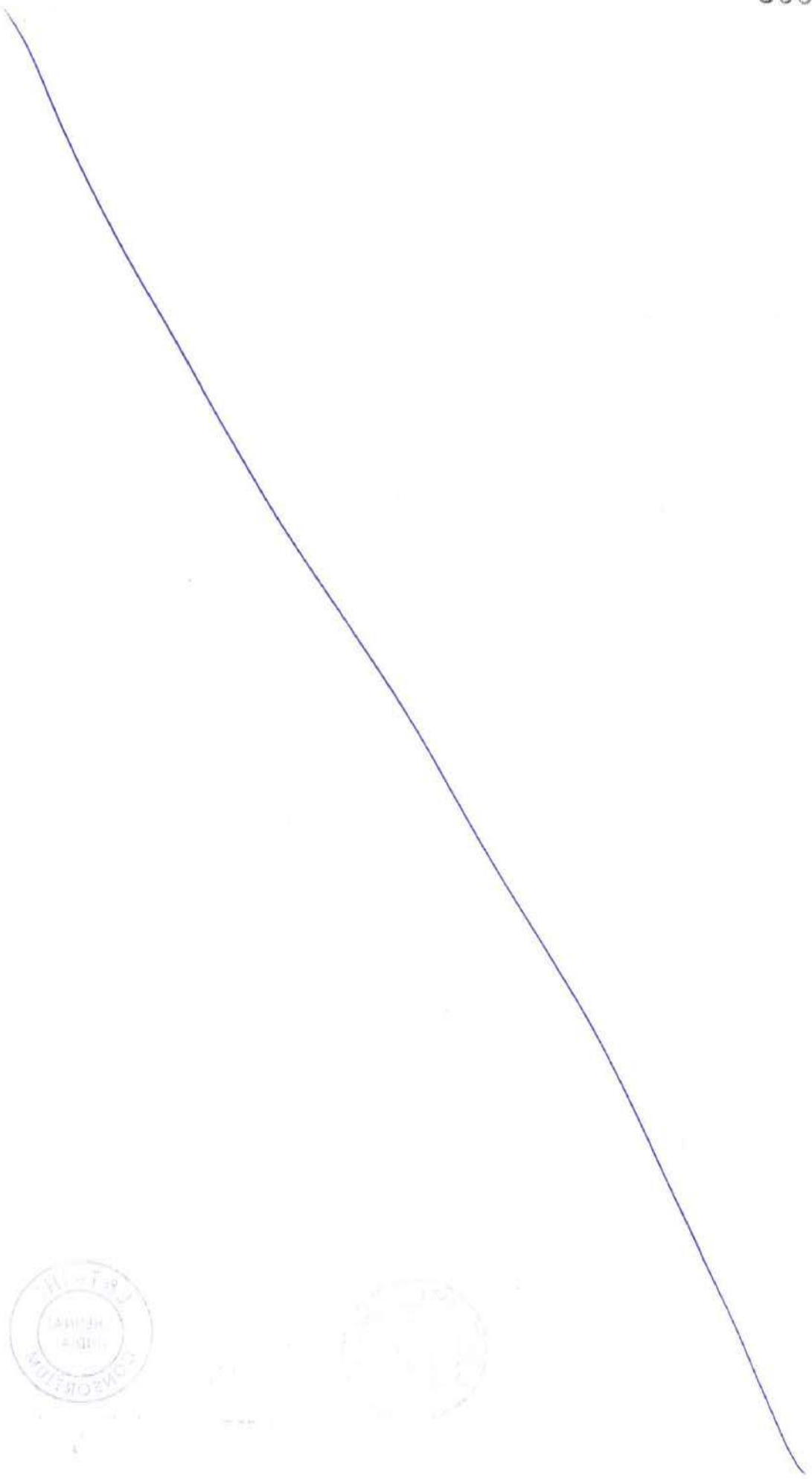


	Sector Undertaking	
5.	Nature of Business: Manufacturer / Vendor / Contractor / Fabricator	

Note: Kindly attach supporting documents wherever it is required.

I/We hereby certify that the information furnished for the above questions are correct and can be subjected to audit/evaluation by client.

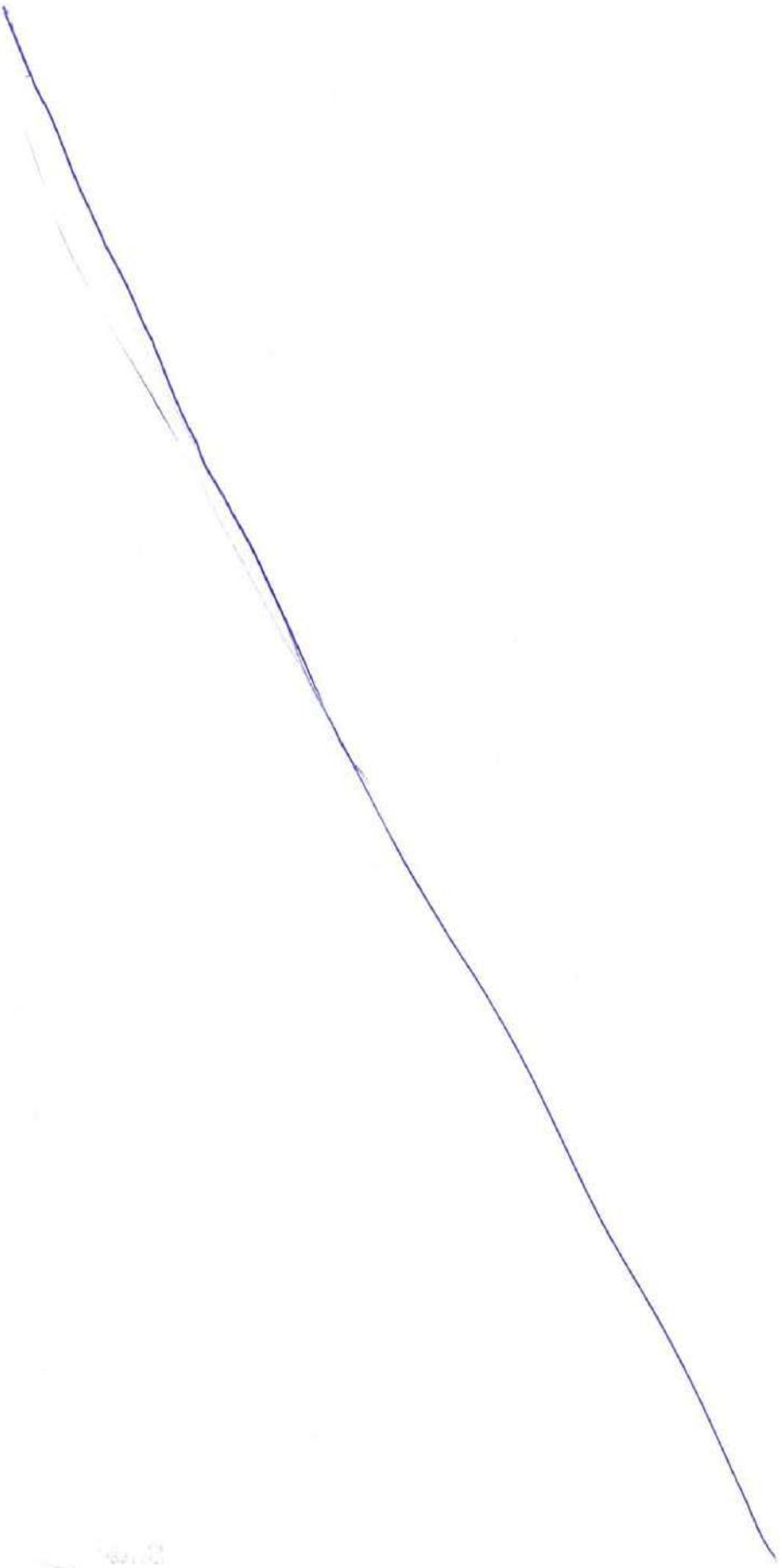
Date: Signature and seal of authorized representative



Quality Assurance Plan

L&T-IHI Consortium VENDOR EVALUATION SHEET

Report No		Contractor: **M/s. L&T-IHI Consortium**
Date		Vendor:
Ref No		
Item		
Criteria/Observation		Comments if any
1. General:		
a) Floor space adequacy for present activity		**Adequate / Not Adequate / NA**
b) Floor space adequacy for expansion		**Adequate / Not Adequate / NA**
c) Housekeeping and cleanliness		**Bad / fair / satisfactory / good / NA**
d) Apparent age of plant		**Old / being modernized / modern / NA**
e) Apparent plant maintenance		**Bad / fair / satisfactory / good / NA**
f) Is working of following satisfactory		
Production planning		**YES / NO**
Quality control		**YES / NO**
g) General order of Workmanship		**Unsatisfactory / satisfactory / good / NA**
h) Records and documentation (availability and up keeping)		**Unsatisfactory / satisfactory / good / NA**
2. Specific to vendor enquiry:		
a. Vendor's understanding and interpretation of :		**Unsatisfactory / satisfactory / good / NA**
i) Scope of work		**Unsatisfactory / satisfactory / good / NA**
ii) Related standards		**Unsatisfactory / satisfactory / good / NA**
iii) Constructional features		**Unsatisfactory / satisfactory / good / NA**
iv) Functional requirements		**Unsatisfactory / satisfactory / good /**
v) QS Requirements		



Quality Assurance Plan

	NA
b. Capability of the Vendor **i) To design and develop** **ii) To fabricate** **iii) To inspect**	**(Based on manpower and facilities)** **Unsatisfactory / satisfactory / good / NA** **Unsatisfactory / satisfactory / good / NA** **Unsatisfactory / satisfactory / good / NA**
c. Ability to provide: **i) Relevant documentary support** **ii) To meet delivery schedule**	**Bad / satisfactory / good / NA** **Bad / satisfactory / good / NA**
3. Recommendation: **(This recommendation is restricted to the tender enquiry and valid for six months only)**	

Assessed by

Name :

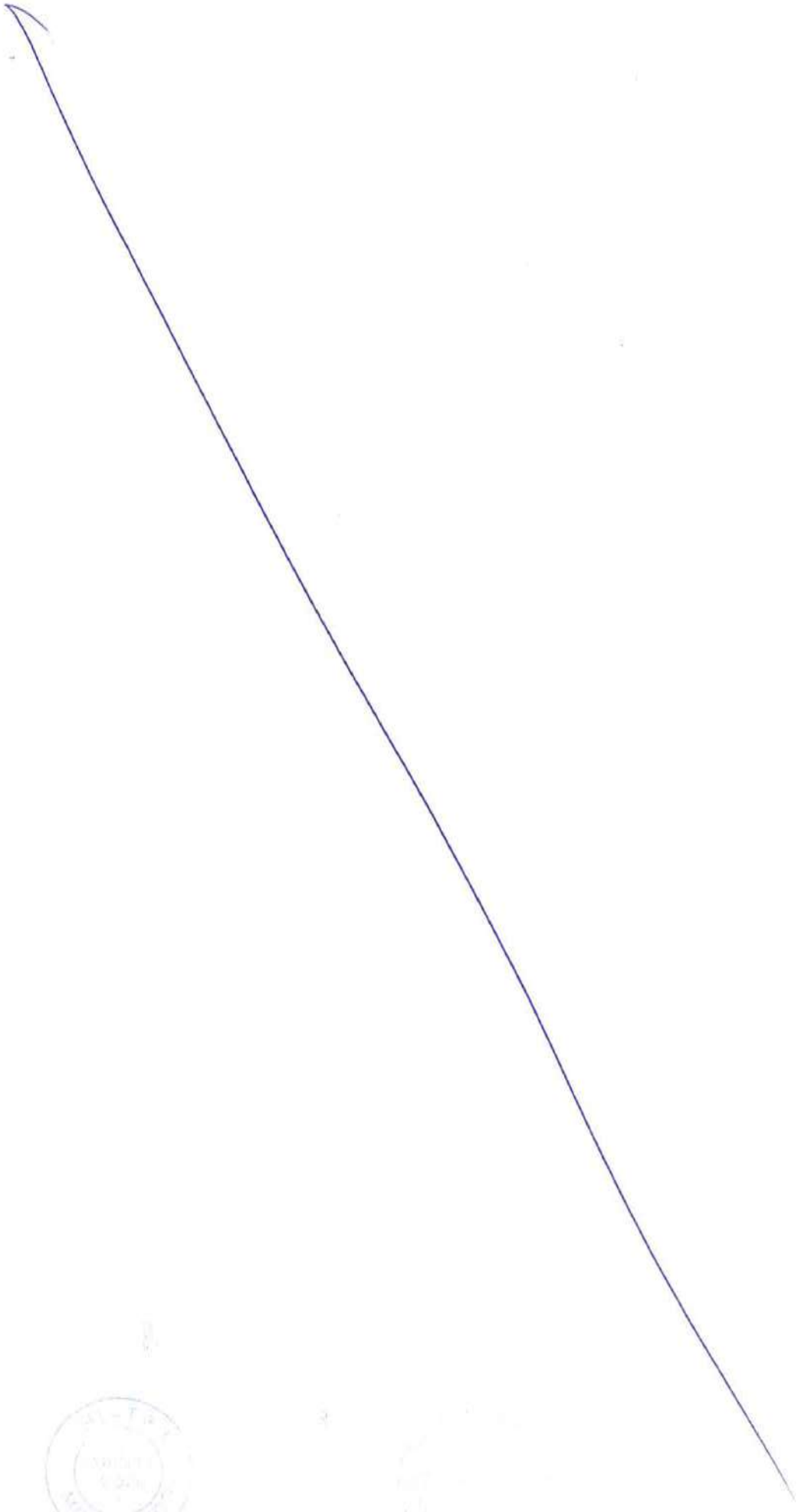
Signature :

MASTER LIST OF VENDORS

Project:

Month:

Date:

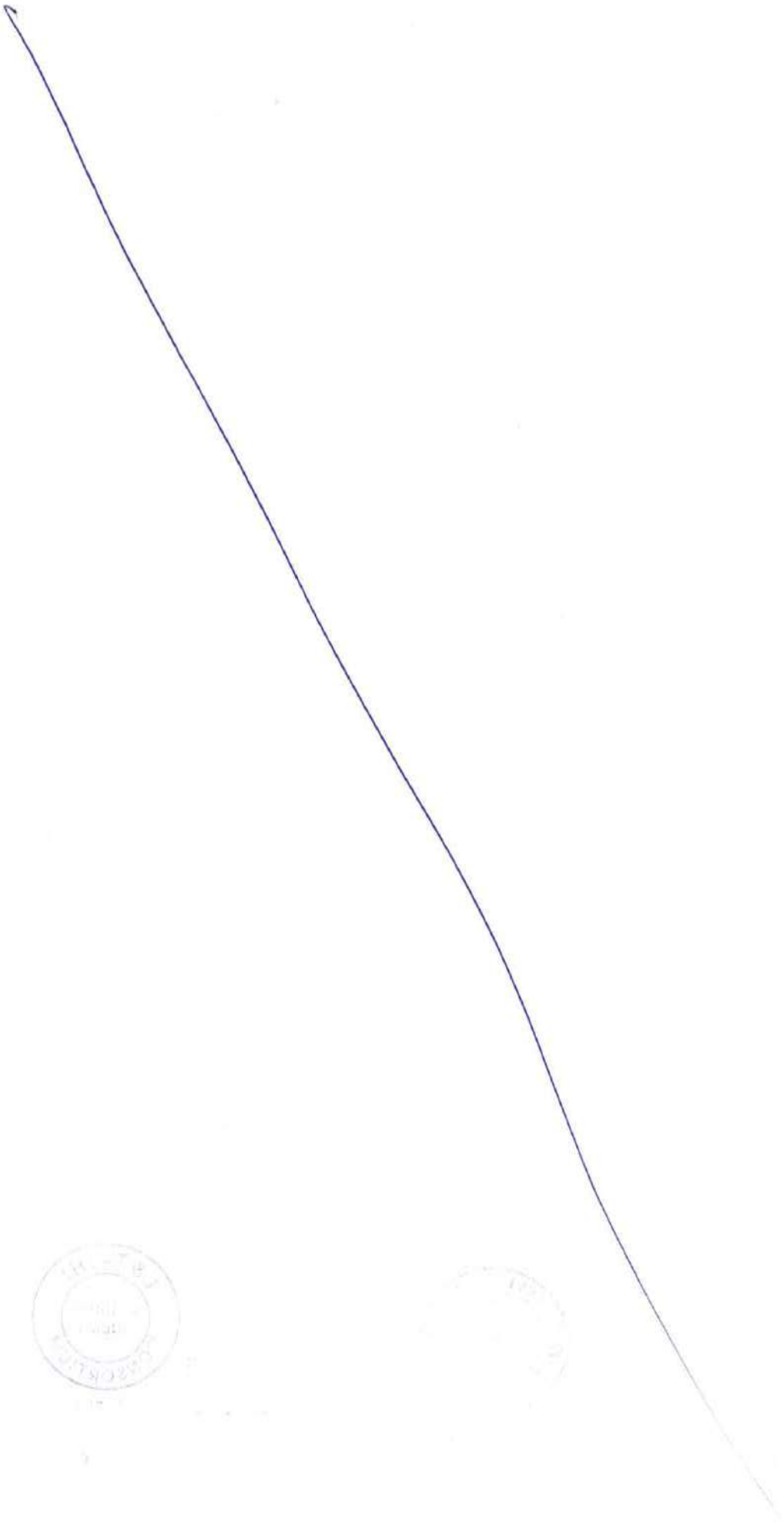


Quality Assurance Plan

Sl.No	Vendor/Supplier Name	PO No & Dt	Scope of Supply	Qty	Remarks

(Planning In charge) **(QA –In charge)**

Note: This list will be updated on monthly basis & submitted to ITER INDIA every month as a part of Monthly Progress Report.



Quality Assurance Plan

Reference ISO Clauses: 6.1, 10.2, 10.3

1. TITLE: Procedure for Risk Management

2. OBJECTIVE:

To define the standard operating procedure for actions to address risk and opportunities during Pre-bid Risk Review Process and Execution (Post-bid) Risk Review Process.

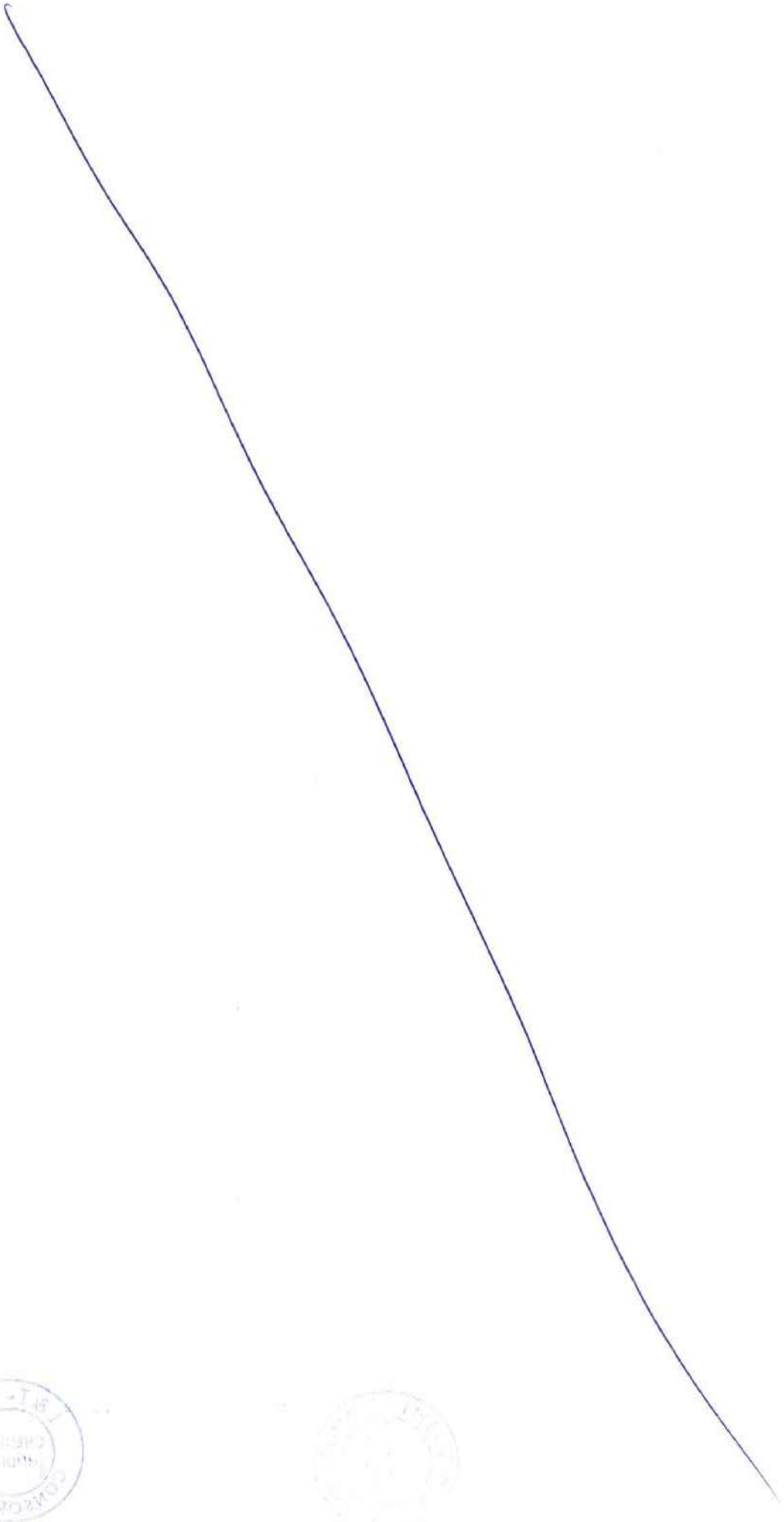
3. SCOPE:

1. Pre-bid Risk Review Process.
2. Execution Risk Review Process.
3. Closeout Risk Review Process (at the closure of the projects)

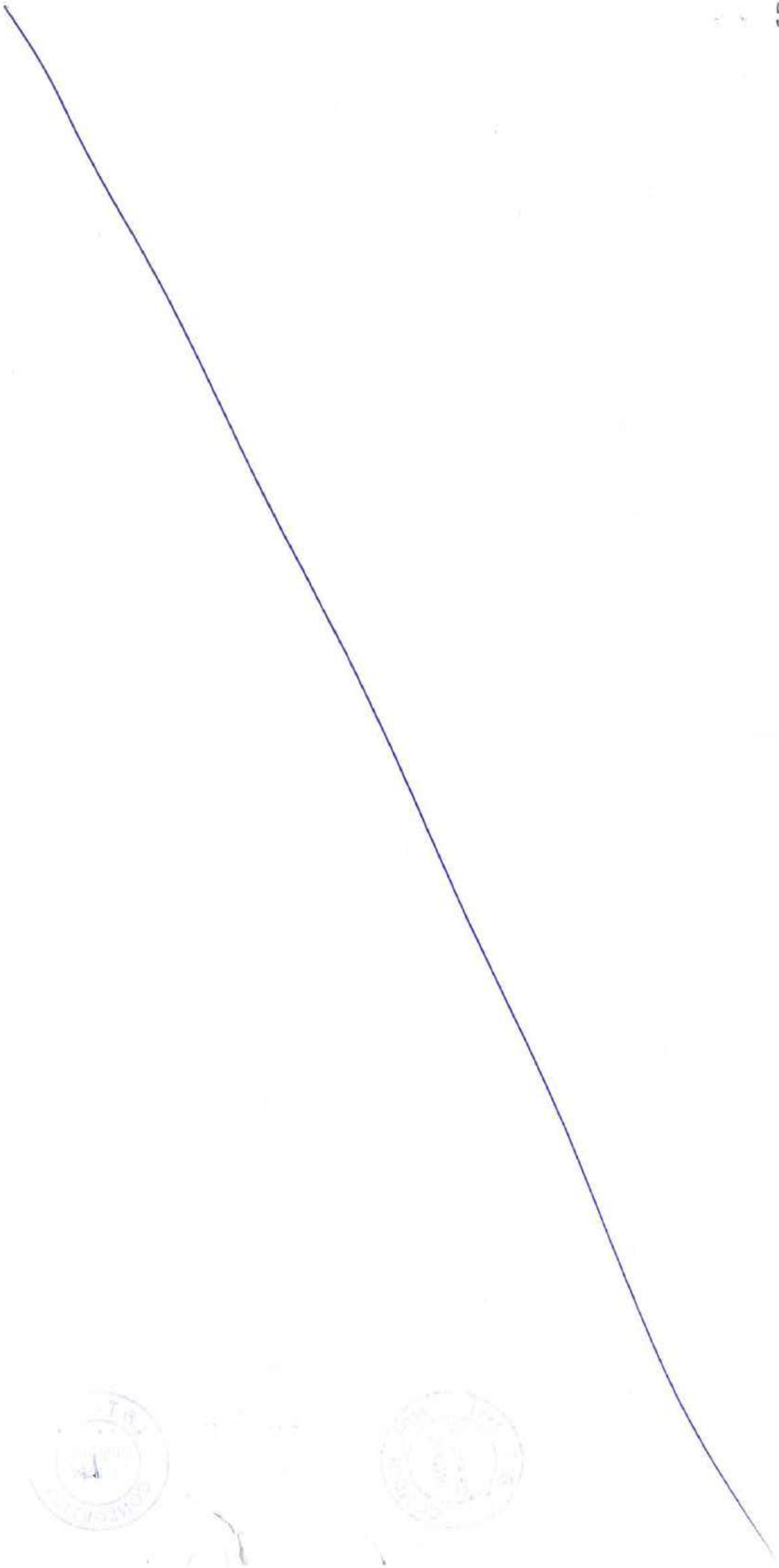
4. PROCEDURE:

- Ensuring that the Pre-bid Risk Review is conducted for all the Tenders which Management intends to bid.
- Conducting Execution Risk Reviews in order to identify and mitigate the Risks during execution stage for all the successful tenders/ ongoing jobs

Sl. No.	Procedure Steps	Responsibility	Reference Document	Record Maintained	Record Distribution
1.0	**Pre-Bid Risk Review Process**				
1.1	Receipt of Tender documents from respective BU tendering team	HOD (CACM)	Tender Document	e-mail	Team member
1.2	Studying and understanding the implications of all the Clauses given in GCC, SCC	HOD/Team Member	-do-	-	Team member
1.3	Sending the	HOD	-do-	e-mail	Risk Dept/Tenderin

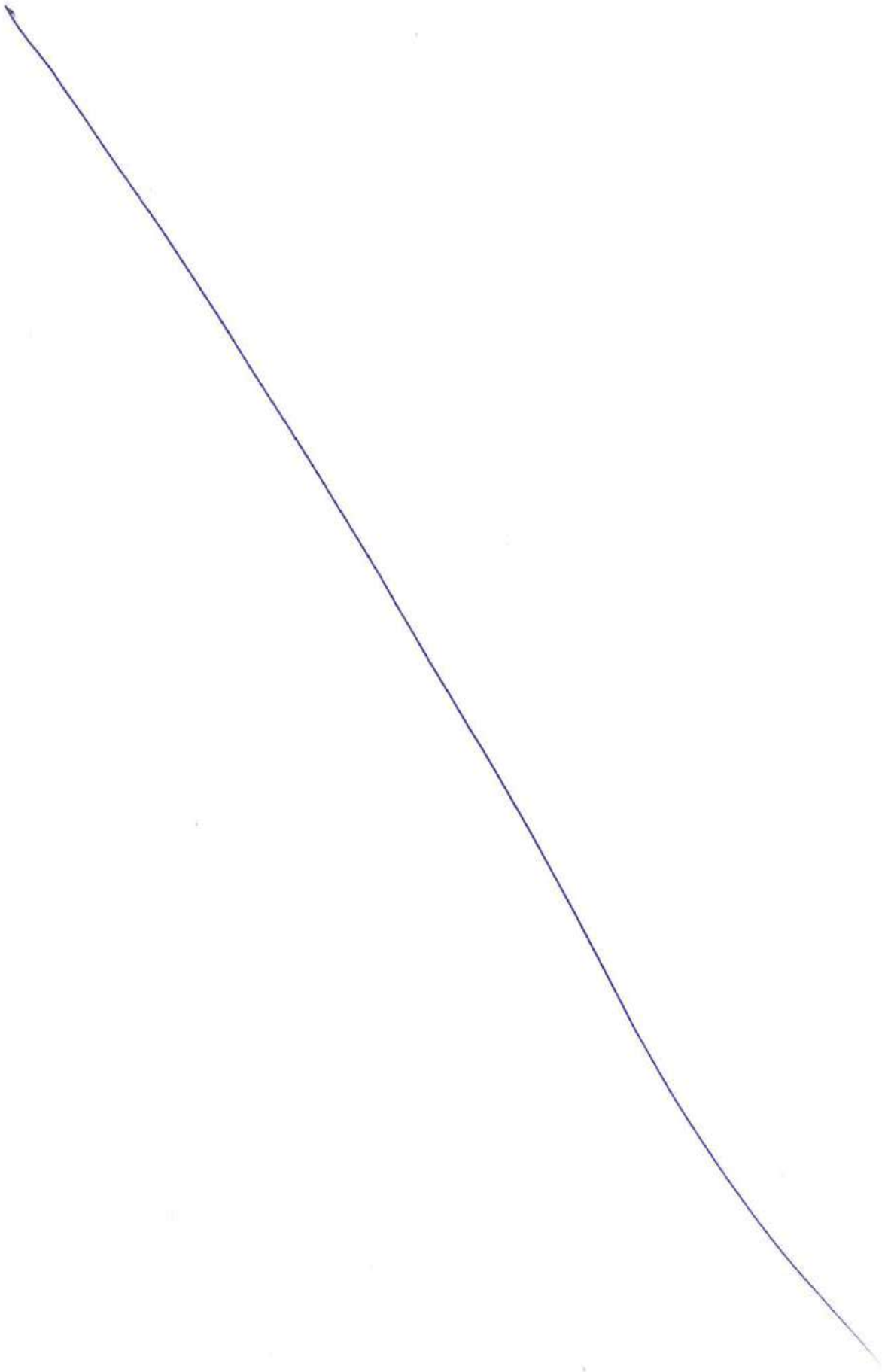


	comments on the various serious and unfair clauses present in the tender to BU head and Tender Department head					g Team
1.4	Conduct Pre-bid Risk Review meeting with different level of approving authority based on the value of the Tender as detailed below in the format provided by the corporate risk management.		Tendering Team	e-mail	Pre-bid Risk Register	-
1.4.1	Discuss/ minute on the means and possibilities of mitigating the Risk and finding opportunities for improvement during the Pre-bid meeting for the identified areas in the above process		Risk Committee	Risk Presentation	Risk Presentation/ Risk Register	Corporate level Risk Committee
1.4.2	Level 1	Approving Authority	Tendering Team	e-mail	e-mail	IC level Risk Team
	up to INR 1,200/- Crs	DMD, IC Head & IC F&A Head				

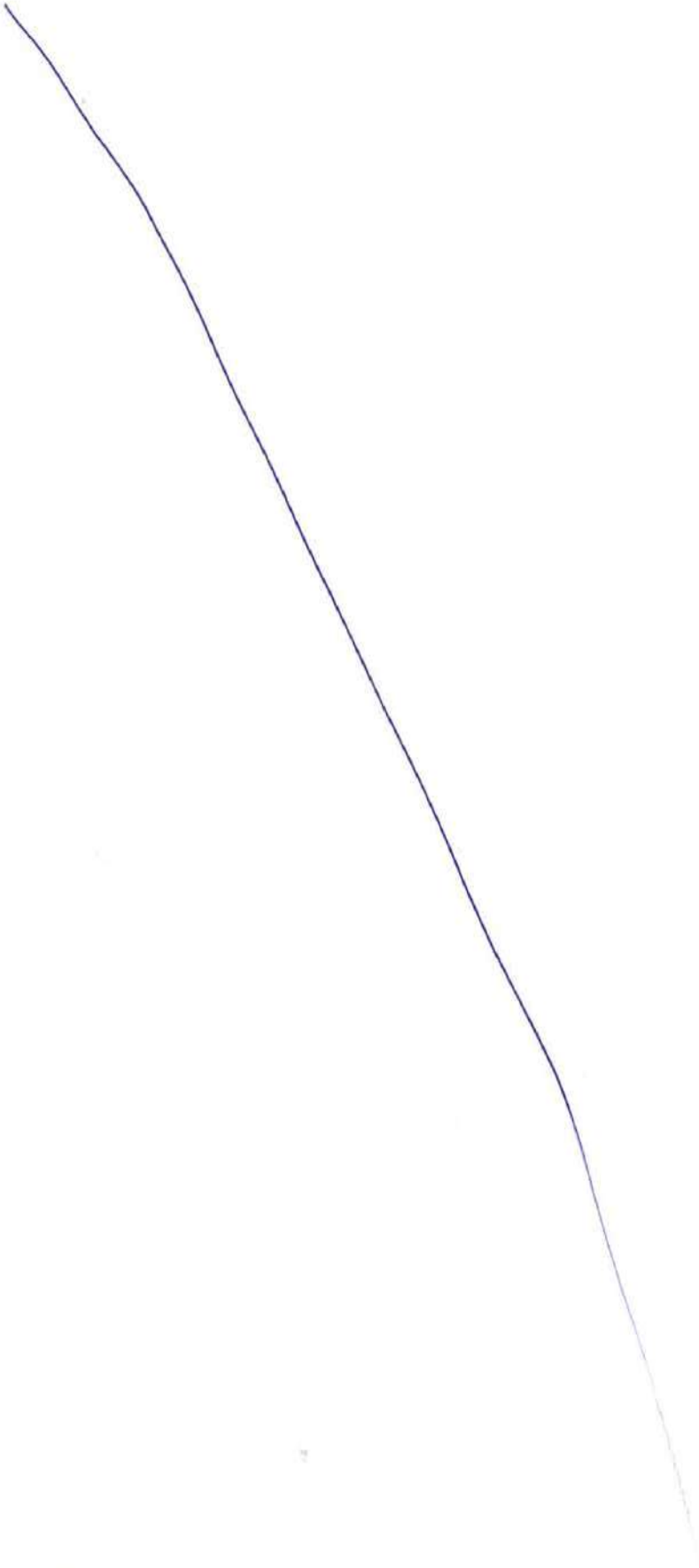


1.4.3	Level 2	Approving Authority	Tendering Team	e-mail	e-mail	Corporate level Risk Committee
	INR 1,200 to INR 2,000 Crs	CFO and Director In-charge				
1.4.4	Level 3	Approving Authority	Tendering Team	e-mail	e-mail	Corporate level Risk Committee
	Above INR 2,000 Crs	GEC				
1.5	Providing clearance for issue of Tender bond based on the outcome of Pre-bid meeting.		Risk Committee			

Sl. No.	Procedure Steps	Responsibility	Reference Document	Record Maintained	Record Distribution
2.0	**Execution Risk Review Process**				
2.1	Plan, prepare and finalize Annual Calendar, containing details of Projects for which Execution Risk Review are to be conducted, in consultation with respective Business Units and obtain	HOD (CACM)	List of ongoing Projects	Risk Calendar	IC & Corporate Risk Committee



	approval from IC head & DMD office.				
2.2	Project Site to prepare Executive Summary and Presentation as per the Standard Template on Risks. Consider the internal & external issues and needs & expectations of interested parties identified while preparing risk assessment.	Project Manager	Risk Template	Risk Presentation	IC – Risk committee
2.3	Conduct ERR either at the Project site or through Video Conferencing. Members from IC / BU / Cluster / Project team /Divisional Corporate & Corporate (Mumbai) Risk Team are the attendees During review, any issues regarding Quantity Variation, Cost Variance, Project Schedule, Cash Flow, BG details, LD, DLP, Risk Provision details etc., would be discussed in a detailed manner so	IC – Risk Team & Site	Risk Calendar, Risk Presentation	e-mail, Risk MOM	IC & Corporate Risk Committee, IC Head/BU Head

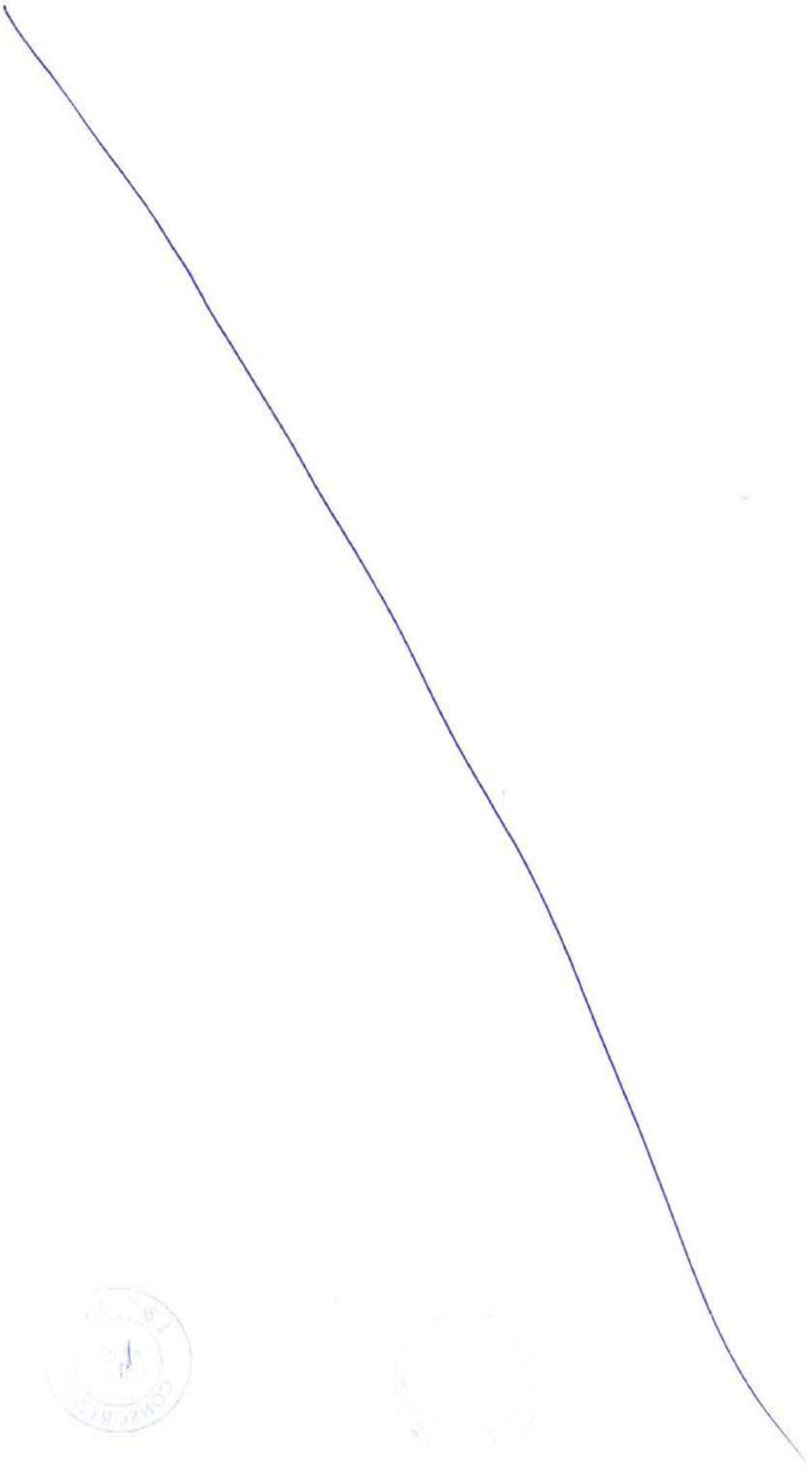


	that the Project objectives are improved.				
2.4	Carryout internal ERRs once in six months. In case of non-achievement of quality objectives, measure impact on organization scope and deliverables , carryout risk assessment & mitigate,	Site	Risk Presentation	MOM/Notes	HOD (CACM)
2.5	Conduct close out Risk Review at the end of the project as per clause 2.2 & 2.3	As per clause 2.2 & 2.3			

4. ABBREVIATION:

A. BG - Bank Guarantee
B. BU - Business Unit
C. CFO - Chief Financial Officer
D. CACM – Contracts Administration & Claim management
E. DMD – Deputy Managing Director
F. DLP - Defect Liability Period
G. ERR - Execution Risk Review
H. GCC - General Conditions of Contract
I. GEC - Group Executive Chairman
J. HOD - Head of Department
K. LD - Liquidated Damage
L. SCC - Special Conditions of Contract

5. RELATED RECORDS:



A. Pre-bid Risk Register
B. Annual Execution Risk Review Calendar
C. Project Executive Summary
D. Project Risk Review Presentation
E. Risk Management – Policy & Procedure Manual

6. A) Input for Pre Bid Risk Review

Risk elements in

i. Political
ii. Economic
iii. Social
iv. Environmental
v. Technological
vi. Legal
vii. Financial
viii. Any other relevant aspects

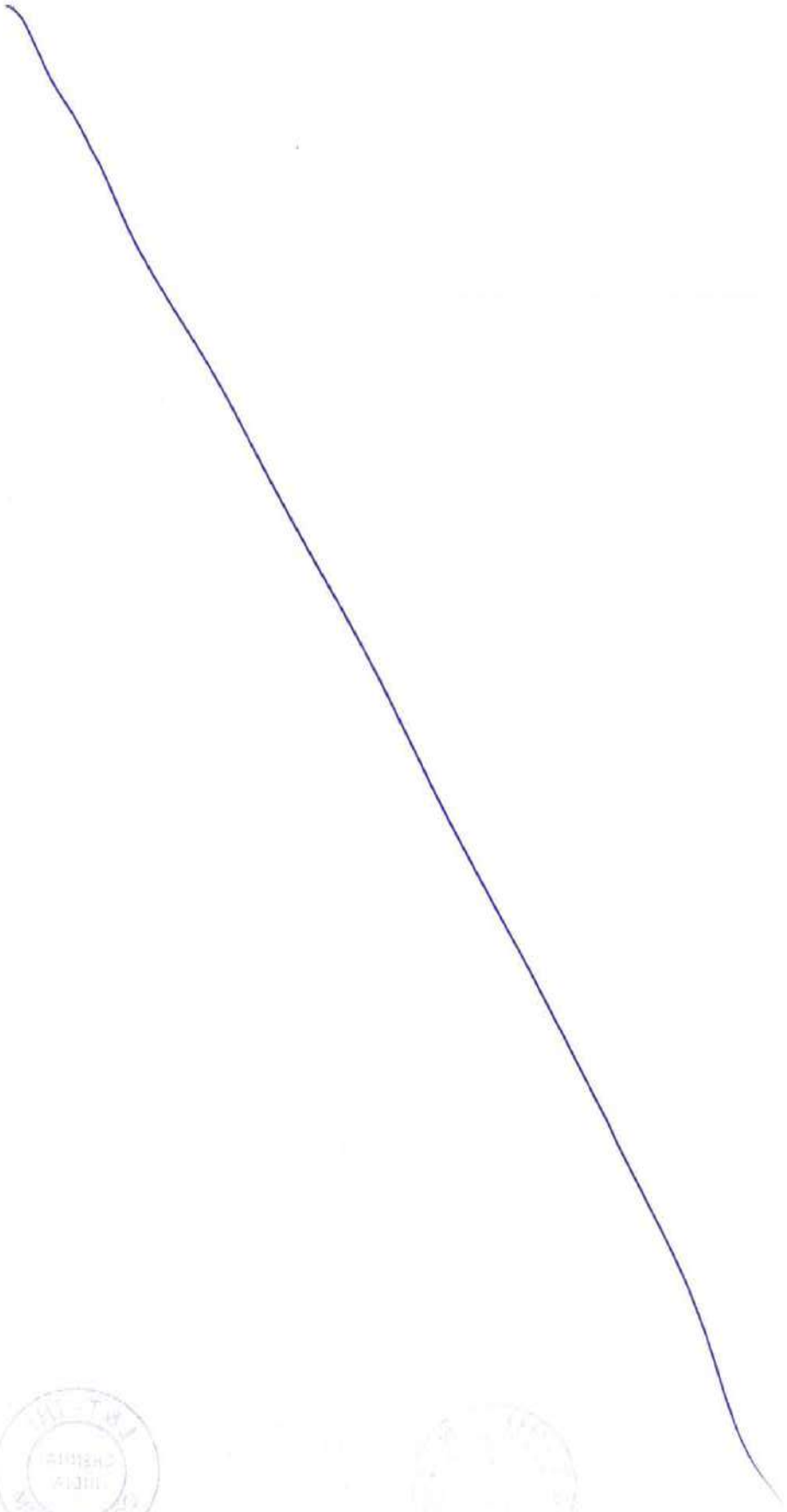
7. B) Input for Execution Risk Review (Ongoing & Closeout)

Elements in

ix. Contractual
x. Financial
xi. EHS & Quality
xii. Resources
xiii. Any other relevant aspects

8. **Output**

a. Risk MOM (for Pre-bid risk review)
b. Project Risk Review Record (for ERR & closeout risk review)



Quality Assurance Plan

Reference ISO Clause: 8.5.2

1. **TITLE: Procedure for Identification & traceability.**

2. **PURPOSE:** Establish, implement & maintain procedure for proper identification and easy traceability of materials received and in process of manufacturing of products at site

3. **SCOPE: Quality Management System (Project Quality Plan)**

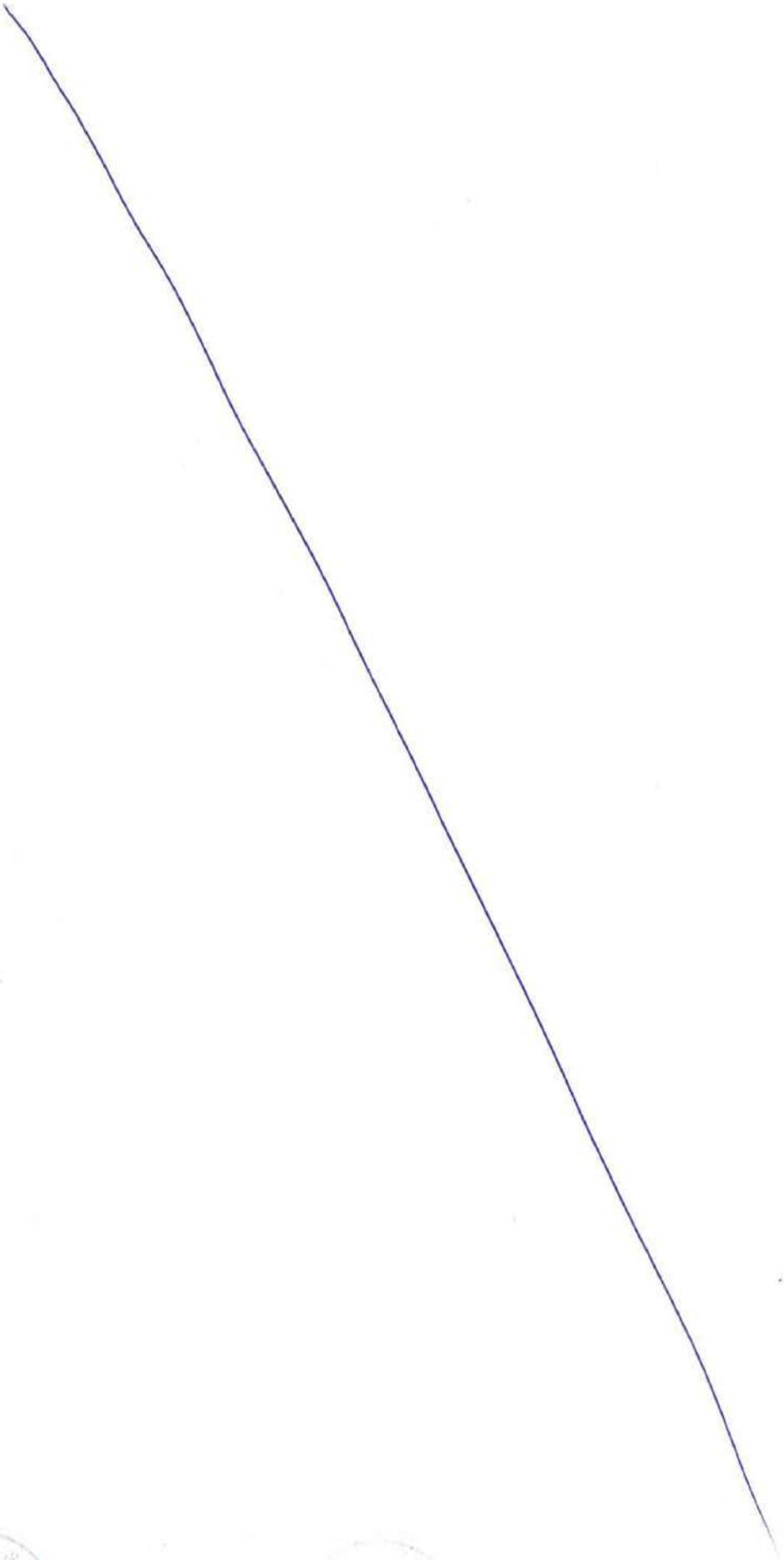
4. **REFERENCE: Procedure / Manual for:**
- Planning
- Safety Manual
- Handling, storage & Preservation.
- Stores manual

5. **PROCEDURE:**

5.1 Stores area:

1) Materials at all stages of inspection are identified with their status as per the below guideline table:

S. No	Descri - ption of Material	Under Inspection			Accepted			Not Accepted		
		On the Mater - ials	Reco- rd Ref	Resp- onsib- ility	On the Materi als	Reco- rd Ref	Resp- onsib - ility	On the Mater- ials	Reco- rd Ref	Resp- onsib - ility
1	**At Stores**		**Materials :**							
a)	Steel : Reinforc ement	Board	MRN DC	Stores	Board	MRN DC	Stores	Red Paint	MRN & Non accept ance report	Design ated staff
b)	Raw material Steel	- Do -	- Do -	- Do -	Accept ed Sticker/ markin g	- Do -	- Do -	Rejec ted Sticker/ markin g	- Do -	- Do -
c)	Cement	-Do -	- Do -	- Do -	- Do -	- Do -	- Do -	Board	- Do -	- Do -
d)	Bricks/ Blocks	- Do -	- Do -	- Do -	- Do -	- Do -	- Do -	Red paint / Rejec ted Sticker	- Do -	- Do -
e)	Pipes	- Do -	- Do -	- Do -	Accept	- Do -	- Do -	- Do -	- Do -	- Do -



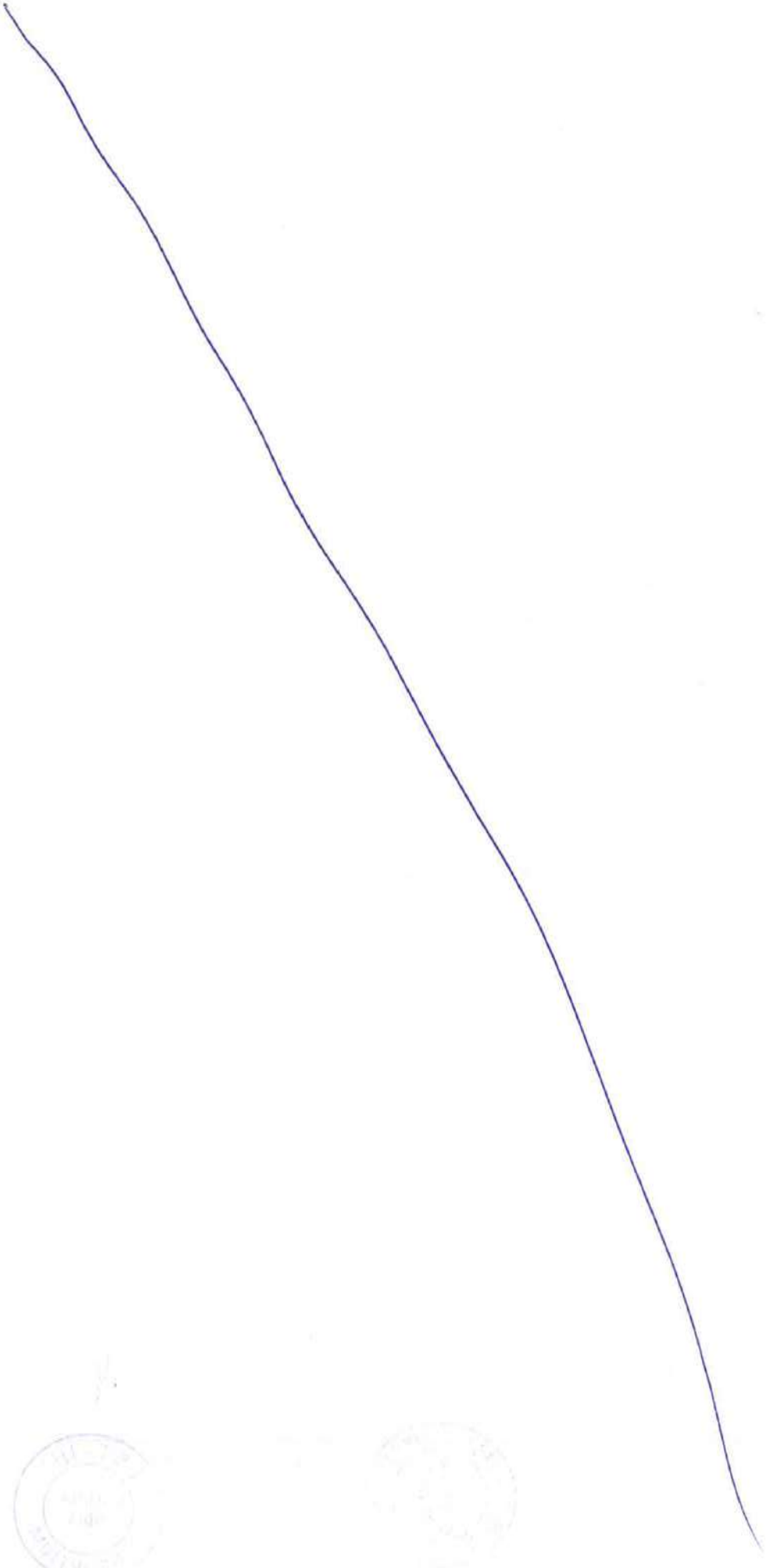
	and Accessories				ed Sticker/ Marking					
f)	Paints	- Do -	- Do -	- Do -	- Do -	- Do -	- Do -	- Do -	- Do -	-Do –
g)	Bolts, Nuts Washers	- Do -	- Do -	- Do -	- Do -	- Do-	- Do -	- Do -	- Do-	- Do -
I)	Other	Board/ Sticker/ Marking	-Do-	-Do-	Board/ Sticker/ Marking	-Do-	-Do-	Board/ Sticker/ Marking	-Do-	-Do-
2	**At location**									
a)	Aggregates/ Bricks/ Blocks	Not to unload from the lorry	MRN/ DC	Designated Staff	Unload location	MRN DC	Designated Staff	Send back the lorry	MRN DC & NAR	Designated Staff
b)	Raw Material steel	Marking /Batch Nos.	MRN/ DC	-Do-	Marking /Batch Nos.	-Do-	-Do-	Marking /Batch Nos.	-Do-	-Do-
c)	In process	Not to start next activity	Check list/ inspection & test records	- Do -	Clear for next activity	Check list/ inspection & test records	- Do -	Rejected Sticker	Inspection Test record & NAR	- Do -
d)	Final Inspection	Checklist/ inspection & test records	- Do -	- Do -	Accepted Sticker	- Do -	- Do -	- Do -	- Do -	- Do -

2) In case of customer supplied material the same procedure given above shall be followed for the identifications or as stated in the product manual.

- **In process area:**

Responsibility: Site section head

9) Identify the stages for identification of the product in work methods / ITP

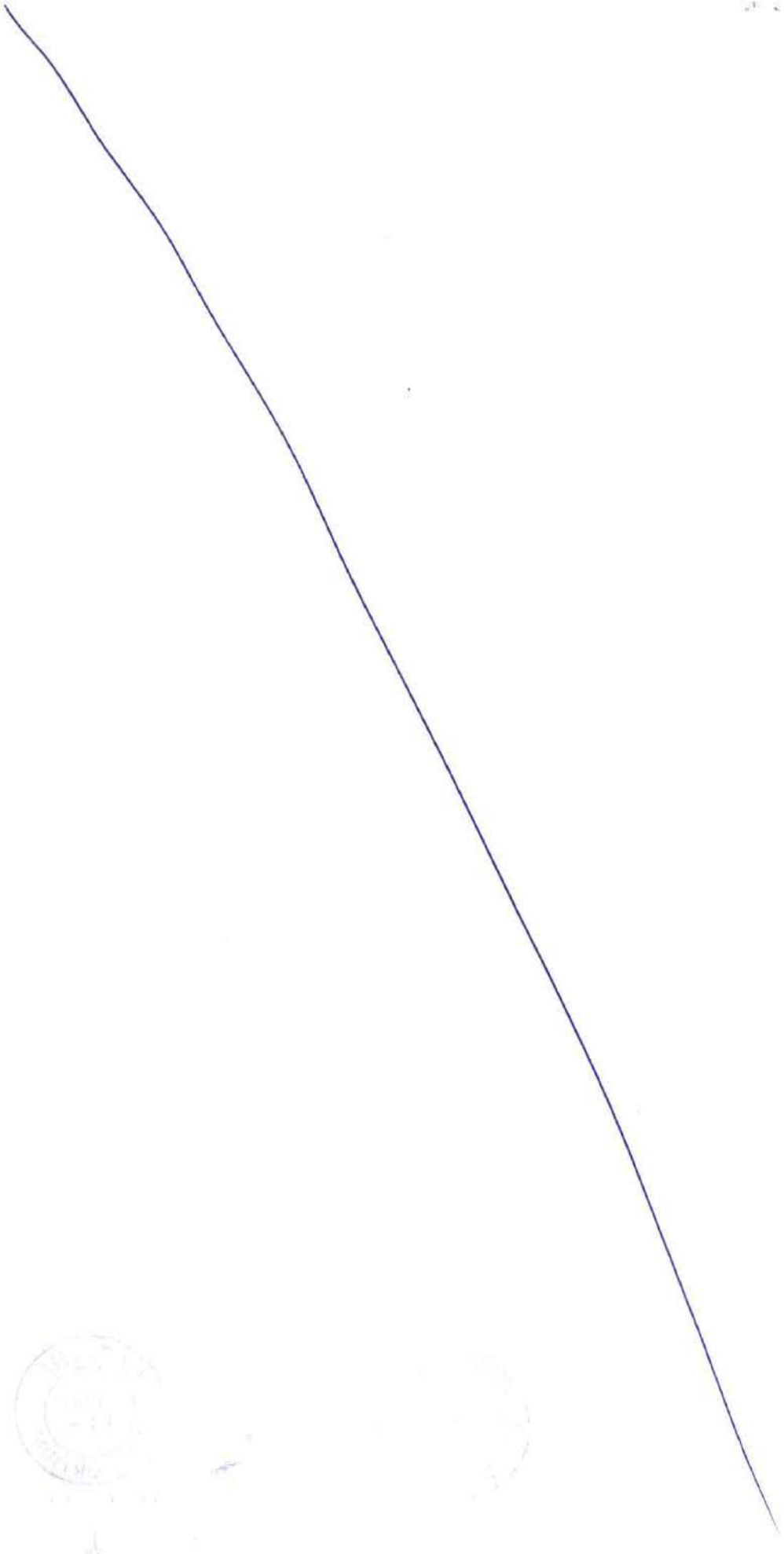


10) In control points of procedure, review the identification status of the product and record wherever necessary the unique identification numbers or codes.

11) Incorporate all the identification nos/codes recorded, in the final product at the time of handing over to customer through necessary documentation / manual for easy traceability.

6. **RECORDS:**

1) Records as per above table.
2) Inspection Records from activities.



Quality Assurance Plan

Reference ISO Clause: 8.5.4

1. **TITLE: Procedure for Receipt, Handling, Storage, Preservation, Issue & control of Material**

2. **PURPOSE:** Establish a procedure for Receipt, Handling, Storage, Preservation, Issue & control of material.

3. **SCOPE:** All materials required for construction of projects. This includes own and customer supplied materials/components.

4. **REFERENCE: Procedure for:**
   a. Selection of vendors & procurement
   b. Identification & traceability.
   c. Safety Manual
   d. Stores manual
   e. EIP / SMS software

5. **RESPONSIBILITY: PRIMARY** : Stores In charge (SI);
   SECONDARY : Section in-charges, Accounts in charge

6. **PROCEDURE: (Also refer the flow chart at the end of the procedure)**

6.1 RECEIPT:

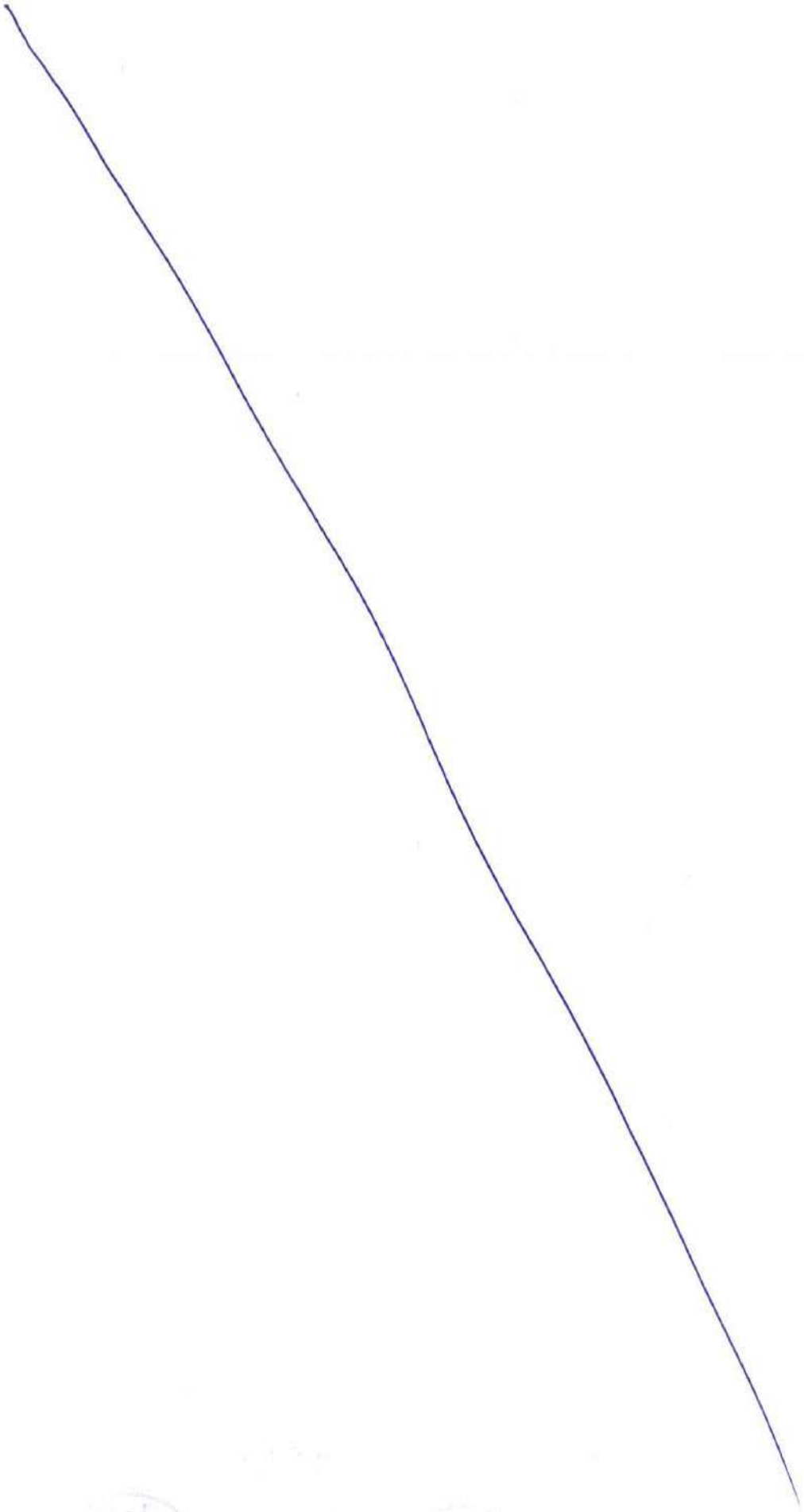
6.1.1 Stores Incharge (SI) along with PM/CM, Accountant and PE shall identify the location for establishing the store facilities. The following points are considered during the identification of a location.

- Scope of work
- Volume of materials to be handled
- Proximity of construction location
- Level of the Ground
- Transport
- Infrastructure etc.,

PM/CM shall arrange all infrastructures as per plan.

6.1.2 SI shall receive materials and arranges for Unloading

6.1.3 SI verifies the materials against the Materials requisition (MR), Purchase Order (PO) received from Purchase In charge and Delivery Challan (DC).



6.1.4 SI shall affix Stamp "SUBJECT TO VERIFICATION/INSPECTION "in lorry receipt' after ascertaining the No of Package / Bundles / Boxes in line with the Delivery slip.

6.1.5 SI shall organizes to segregate the materials as

- Consumables
- Raw Materials
- Spare Materials
- Bolts & Nuts and Washers
- Other materials

and verifying the individual item for correct quantity. SI communicates vendor in writing through Purchase In charge (PI) if any shortage/ damage is found for necessary action.

6.1.6 SI prepares " Material receipt note (MRN) and arranges for inspection through designated staff by handing over the MRN, DC & PO

6.1.7 Designated staff inspects as per quality plan (QP), Specification, purchase order.

6.1.8 SI shall compile all the papers - MRN, PO, DC, Bill & non acceptance report (if any) to PM/CM for his approval and Accounts for further action.

6.2 HANDLING

6.2.1 Maintain a list of Perishable materials to ensure "first in -first out". Keeps monitoring the shelf life of material and informs the PE & QA for necessary action.

6.2.3 Follow applicable test for perishable items if in storage for a long time. .

6.2.4 Follow housekeeping instructions as per safety manual, for preservation of intermediate / end product.

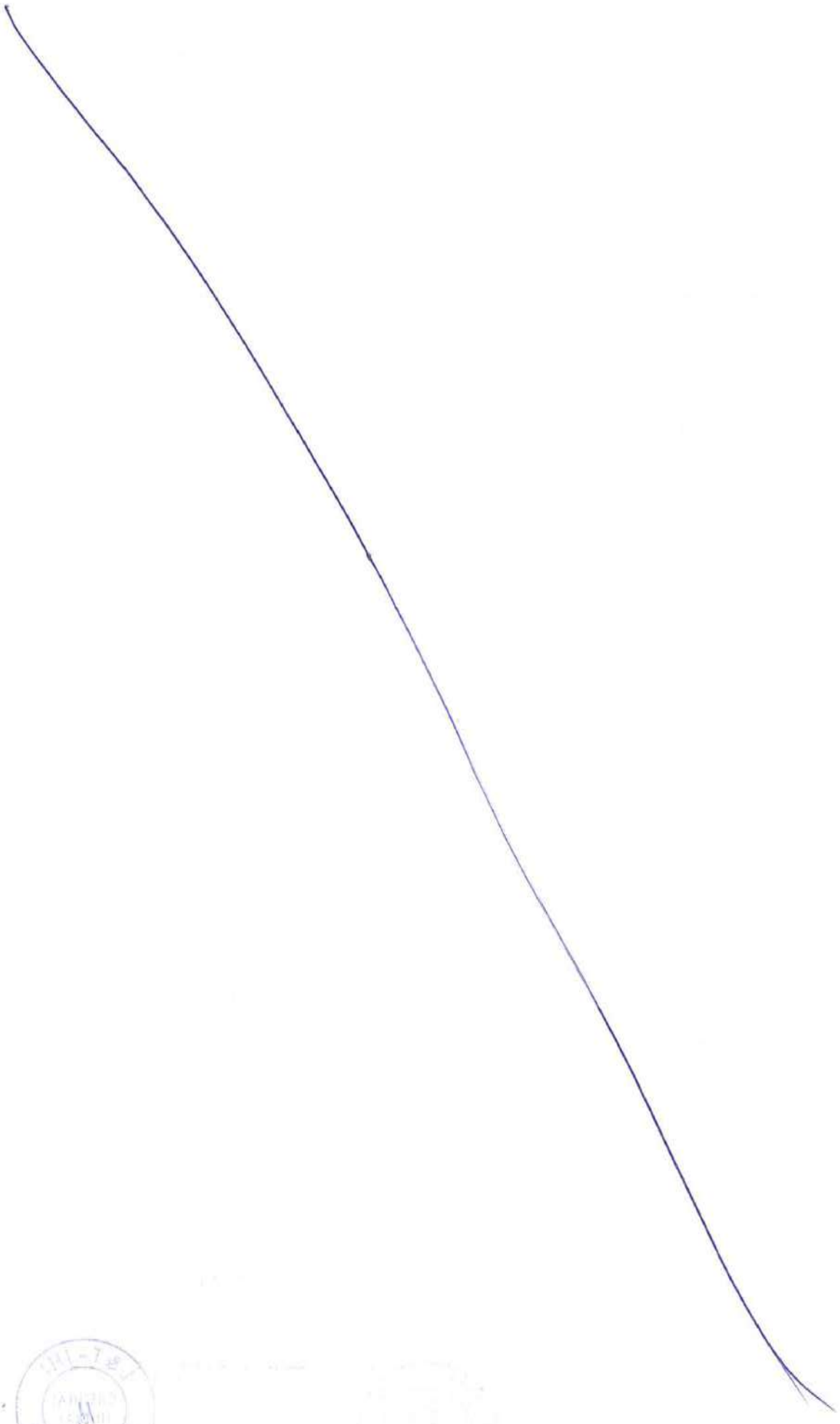
6.2.5 SI shall arrange to stack the accepted materials in the designated area.

6.2.6 Rejected materials shall be handled as per the directions of inspection Report. Accepted and rejected materials are identified as per procedure for identification & traceability.

6.3 STORAGE

6.3.1 Materials shall be identified & coded as per Stores manual.

6.3.2 Materials shall be stored as per the requirement including special storage such as cement, paints, chemicals, etc.



6.3.3 Periodic verification of the materials shall be carried out to check and ensure the materials are in good condition. SI shall take necessary steps for improvements in the facilities for proper storage if required.

6.4 PRESERVATION

Responsibility: Store In-charge & Section in-charge

6.4.1 The materials shall be preserved as per the requirements of the manufacturer, where manufacturer specs are not available enough care shall be taken to preserve the same to maintain its properties.

6.4.1 After the product is manufactured or construction is completed, the same shall be kept in good condition until it is handed over to customers. This covers part /full completed project till it is handed over to customer.

6.4.2 Where handing over in stages the necessary records will be maintained and after final handing-over, necessary completion certificate is obtained from customer.

6.5 DELIVERY

Responsibility: Section in-charge

6.5.1 Plan pre-delivery activities and prepare a checklist to identify areas that are critical.

6.5.2 Review and ensure the correctness of the product suiting the requirements of customer.

6.5.3 Wherever required prepare 'do' and 'don'ts' manual or the precaution to be taken at the time of usage of the product and specification of the product in brief.

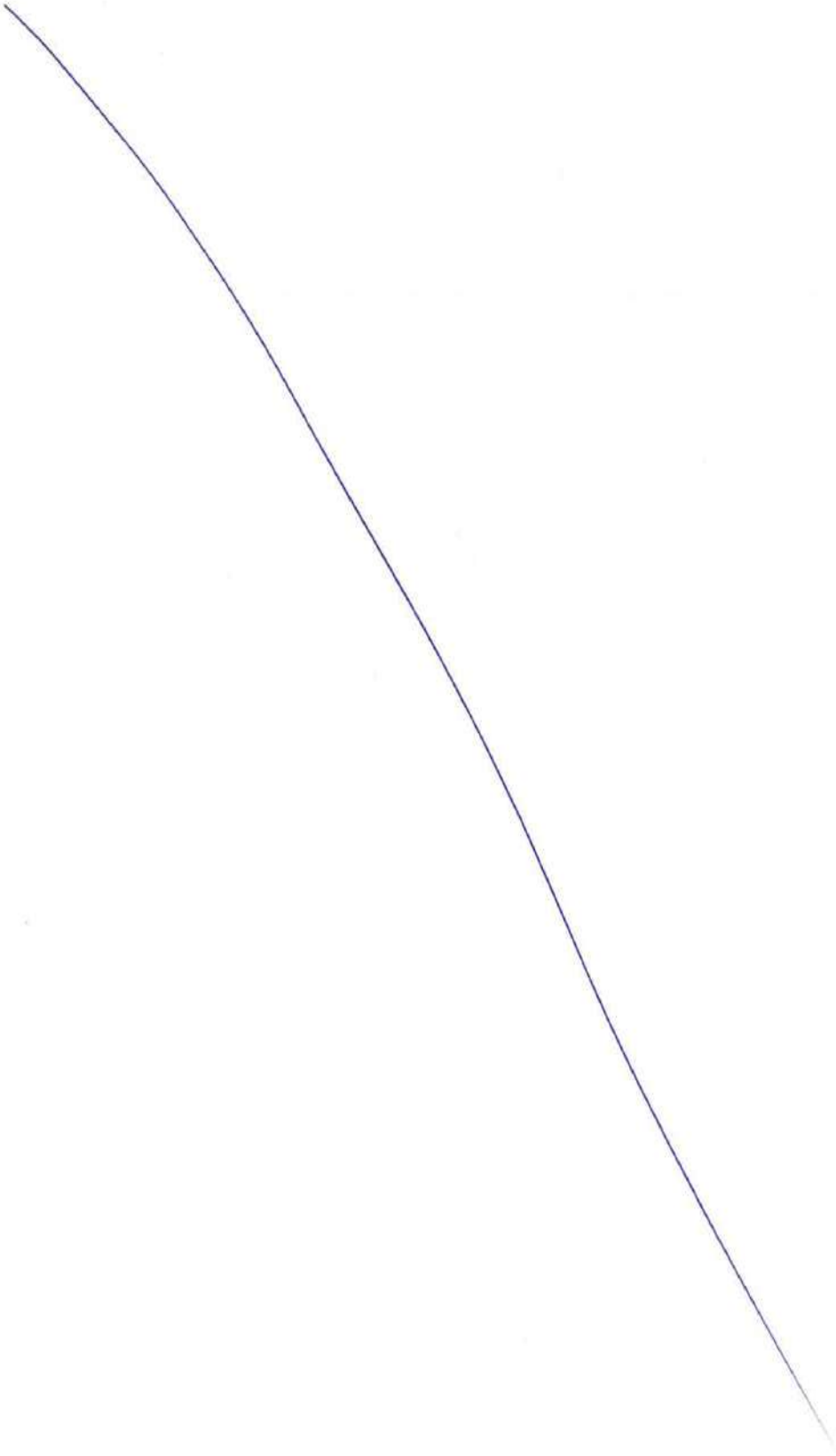
6.5.4 Handover the product to customer as above and also the defect liability / warranty details if any and take customer acknowledgement.

6.6 ISSUE MATERIALS:

6.6.1 SI shall issue the materials as per the Indent of user department after verifying purchase requests as applicable.

6.6.2 SI shall verify the following before issue of materials

- Signature of Authorised Person as per authorisation list issued by PM/CM
- Cost Code



- Material Code (if any)
- Unit of measurement
- Quantity
- Availability of Stock

6.5.3 Materials are also despatched as per the requisition to other sites in case of excess or on completion of project.

6.7 MONITORING & CONTROL:

6.7.1 SI shall prepare monthly stock statement after updating all the indents.

6.7.2 SI shall arrange to carry out the perceptual physical stock verification and reconcile the same against the book stock of verified items.

6.7.3 SI shall also verify the daily stock position of critical item and inform the same to PM/CM & PE.

6.7.4 Suitable software package like Site Material System (SMS) shall be used to maintain stores system. In such cases records of stores like Material receipt note, Material Issue Book, Statement of Inventory and Stock Register / Material card shall be maintained in electronic media.

6.7.5 Refer the attached flow chart for the material purchase procedure.

6.8 CUSTOMER / EXTERNAL PROVIDER SUPPLIED MATERIALS & PRODUCTS:

6.8.1 SI shall receive materials from customer / external provider or their representative to be used in the construction of project as per the advice of PM/ PE.

6.8.2 SI shall handle the customer/external provider supplied material in the same manner (receipt, inspection, handling, storage, preservation, delivery. Issue & monitoring & control) as our own material once it is received.

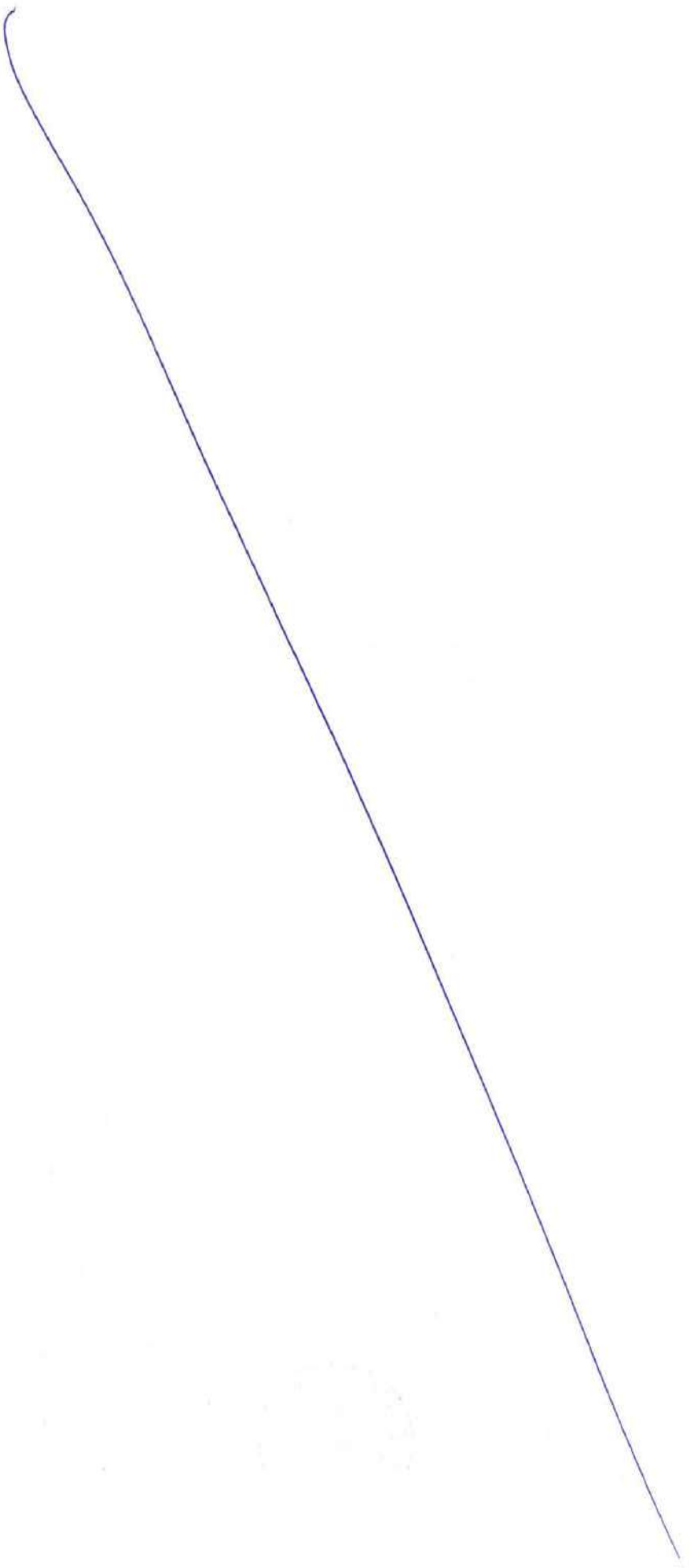
6.8.3 SI shall verify the quantity in the packages against the quantity in Delivery slip/ Challan and prepares "customer / external provider supplied material verification report "including any damages / losses noticed.

6.8.5 SI shall send a copy of customer/ external provider supplied material verification report along with original LR, DC & Packing List to planning dept. for their action.

6.8.6 SI shall maintain separate MRN for customer/ external provider supplied products.

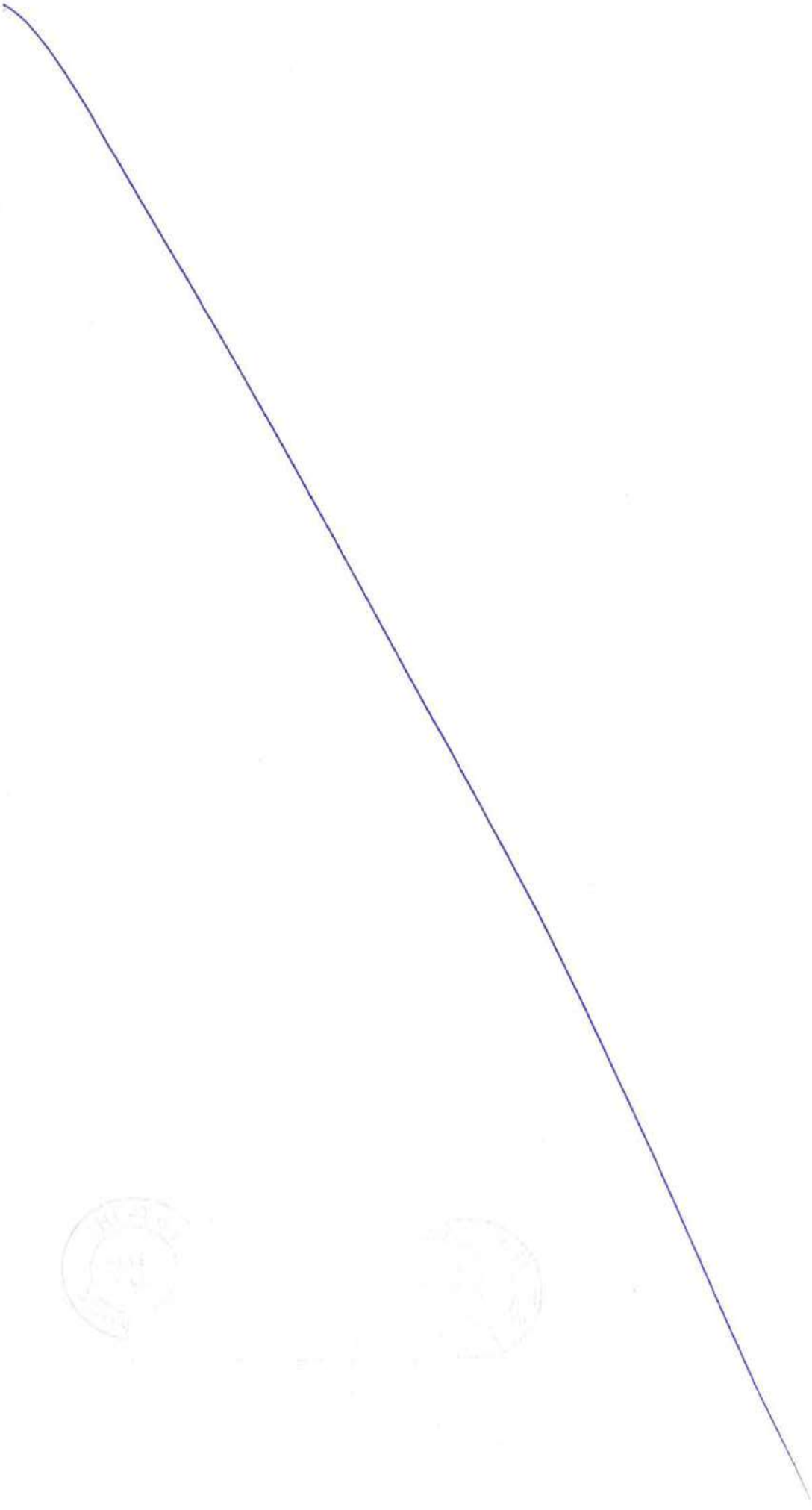
6.8.7 SI shall reconcile the stock of customer / external provider supplied materials once a month and prepares stock statement.

6.8.8 SI shall maintain separate MRN, Indent, Bin Card, Stock Register etc., for customer/external provider supplied materials for easy clarification and reconciliation.



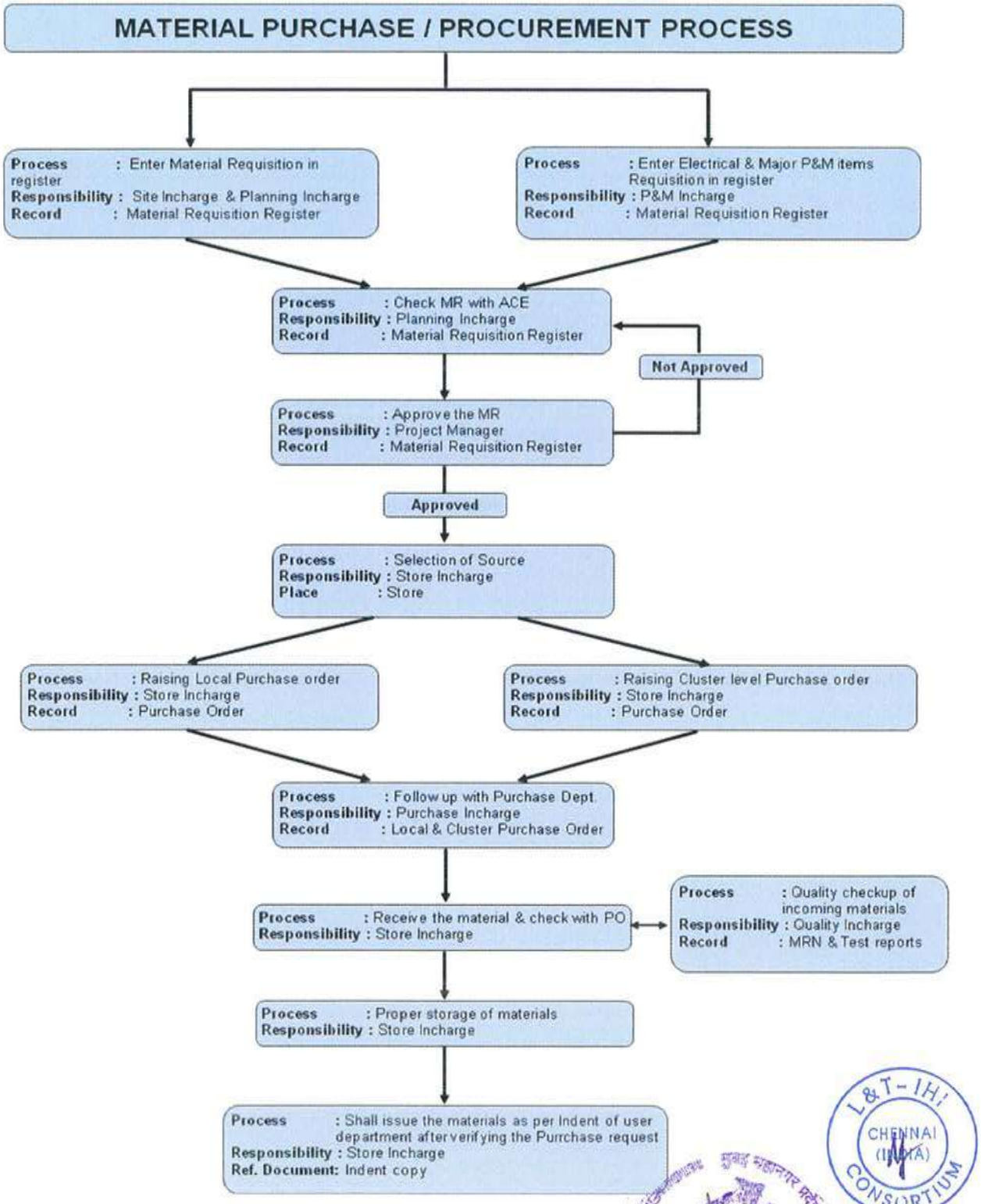
7. RECORDS:

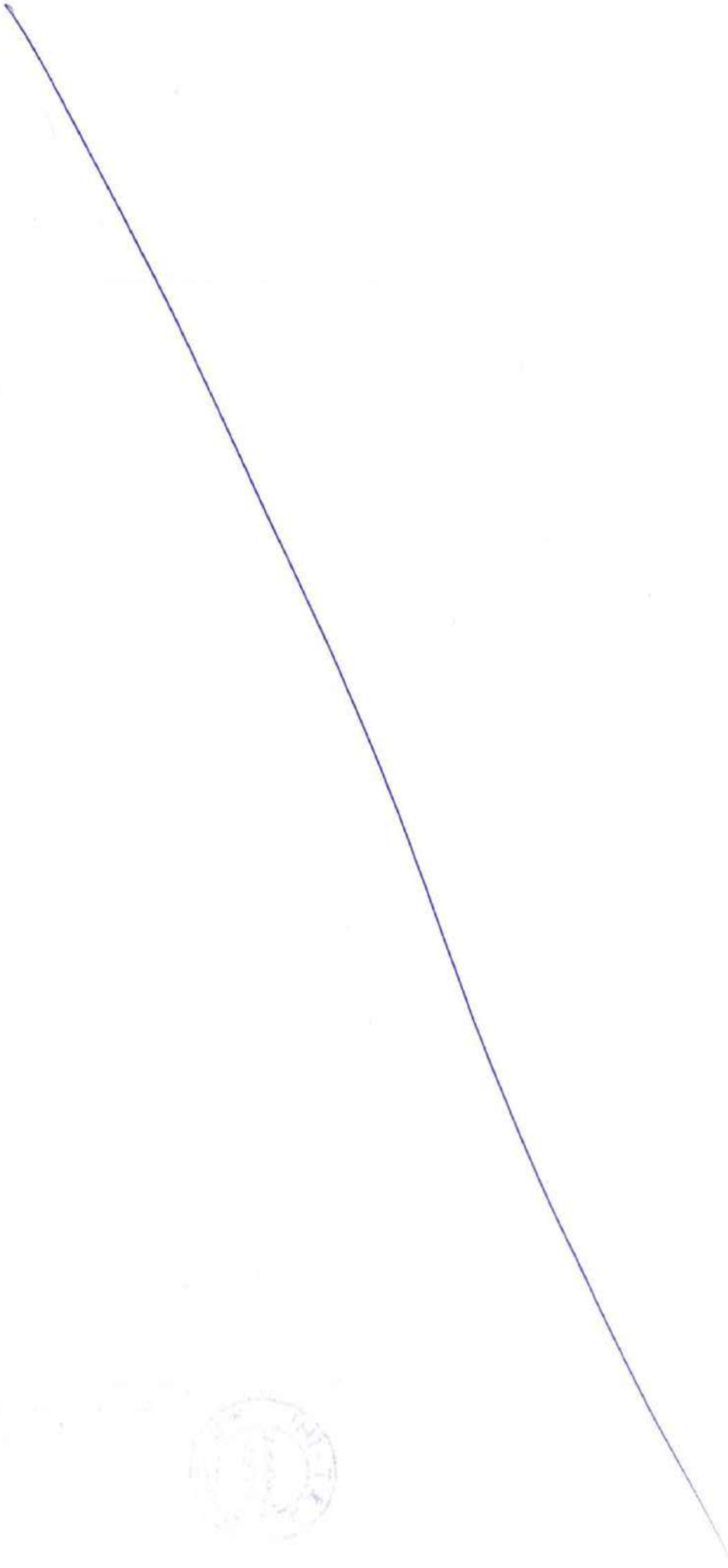
1. Work Instruction for Handling of Material at Stores / Stores manual
2. Material Requisition
3. Purchase Order
4. Delivery Challan / Bill
5. Indent
6. Material Receipt Note
7. Customer / external provider supplied material verification report
8. Material Issue Book
9. Statement of Inventory
10. Receiving Inspection records



Quality Assurance Plan

FLOW CHART FOR MATERIAL PURCHASE / PROCUREMENT PROCEDURE





Quality Assurance Plan

Reference ISO Clause: 7.1.5

1. **TITLE: CONTROL OF MONITORING & MEASUREMENT EQUIPMENT**

2. **PURPOSE:** Establish and maintain a procedure for calibration and maintenance of the inspection and test equipment to ensure that the equipment is capable of performing to required accuracy.

3. **SCOPE:** Quality Management System (Project Quality Plan)

4. **REFERENCE: Procedure for:**
   Management Review
   Corrective actions
   Risks & Opportunities

5. **RESPONSIBILITY: PRIMARY:** QA/QC Engineer

6. **PROCEDURE:**

6.1 Prepare list of measuring equipment required, ensure adequate care is taken while selecting the monitoring and measuring instrument with suitable specifications, including range to be measured, accuracy and robustness under specific conditions.

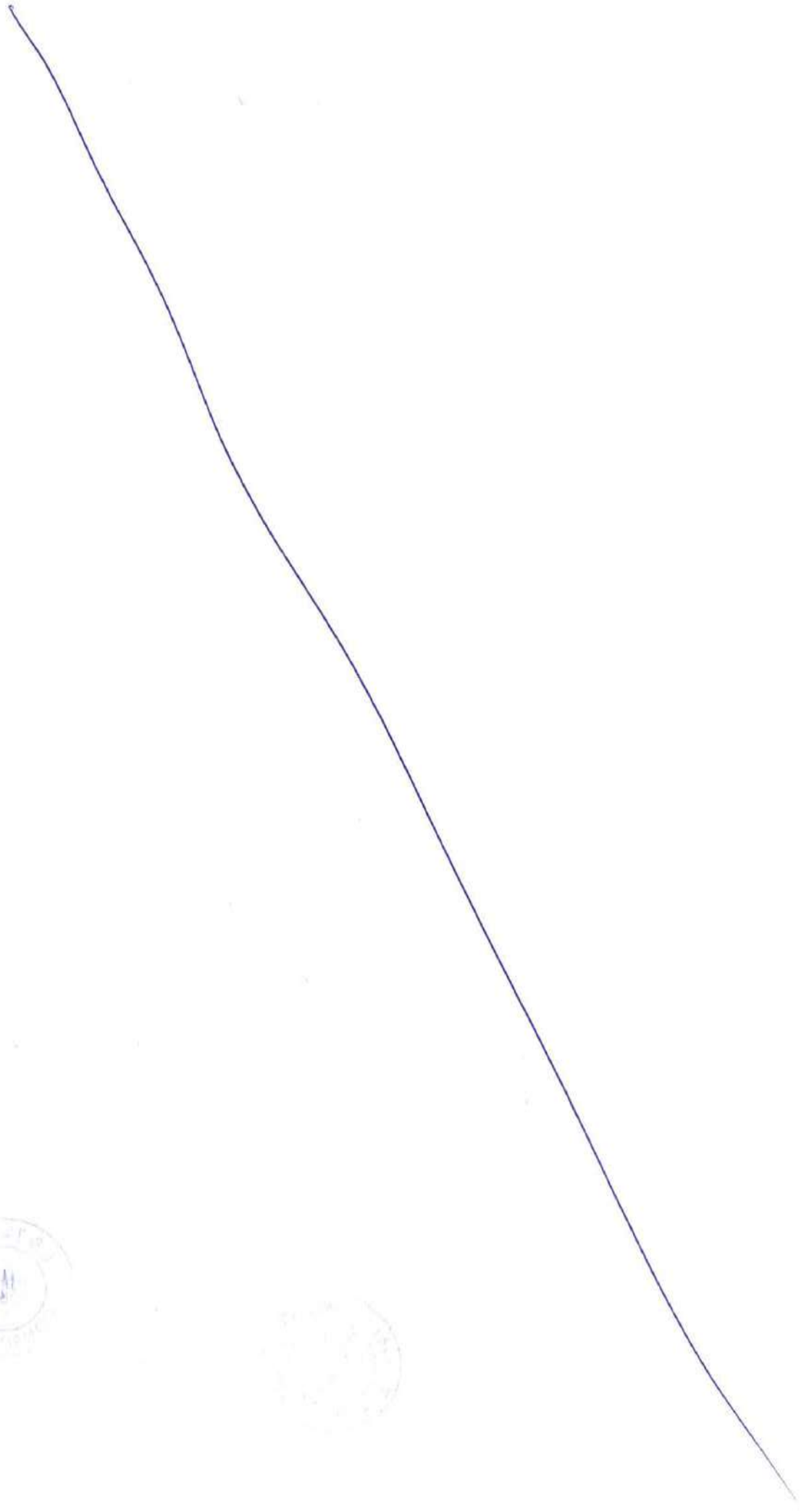
6.5 Identify list of equipment requiring initial calibration prior to first use (both Internal & External)

6.6 Prepare method of internal calibration (If Required)

6.7 Prepare the process of measurement and ensure that monitoring & measurement is carried out as per the requirement.

6.8 Identify list of equipment's regarding statutory items like weights and measures. Calibrate & stamp it with government agency of weights and measures department.

6.9 Prepare sequence of calibration and location



6.10 Calibrate testing equipment to traceable international or national measurement standards and maintain record. Wherever acceptance criteria not available as per standards or code, define acceptance criteria according to usage.

6.11 Protect from damage and deterioration during handling, Maintenance and storage.

6.12 Maintain the record indicating the unique identification of instrument, frequency of recalibration, calibration status.

6.13 Assessing and documenting the validity of previous inspection & test results when Non-conformity is found and take appropriate action on the equipment.

6.11 If any software is used for the purpose the ability of the same to satisfy intended application shall be confirmed prior to use.

7. RECORDS:

1. List of Instruments for Calibration – WP 14 F01

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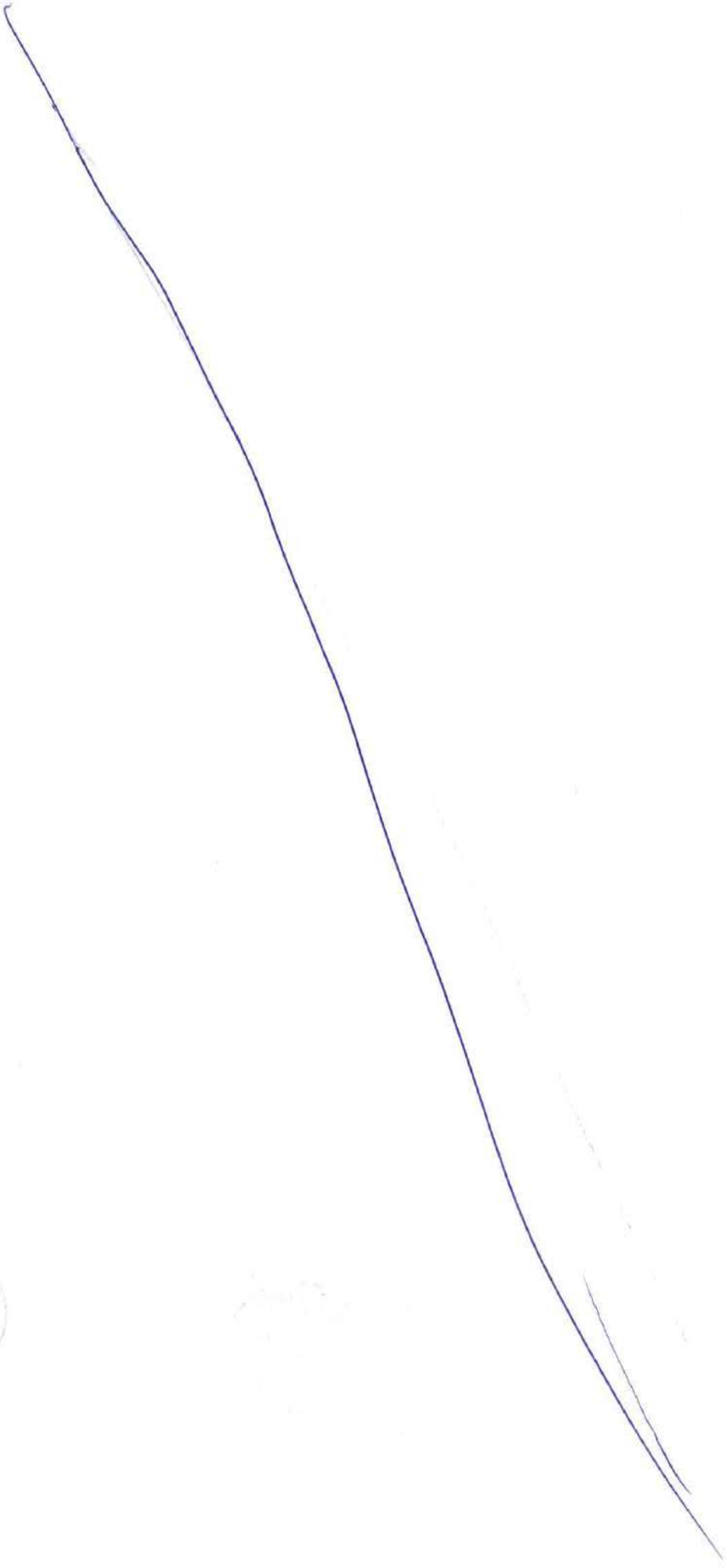


Quality Assurance Plan

Reference ISO Clauses: 5.1, 7.1, 8.2, 10.2 & 10.3

1. **TITLE: PROCEDURE FOR CUSTOMER FEEDBACK**

2. **PURPOSE:** Establish, implement & maintain a procedure for Customer feedback and analysis of the same for improvement.

3. **SCOPE:** Quality Management System (Project Quality Plan) – All processes & products

4. **REFERENCE: Procedure for:**
   - Management review
   - Internal audits
   - Corrective action
   - Risks & Opportunities
   - Project planning

5. **RESPONSIBILITY: PRIMARY:** Project in-charge; **SECONDARY:** All section Heads

6. **PROCEDURE:**

CUSTOMER COMPLAINTS THROUGH LETTER

6.1 Record the Customer complaint and acknowledge the receipt of the same.

6.2 Discuss the Customer complaint
   - Examine root causes.
   - Identify & implement corrective action
   - Assess Results
   - Inform customer
   - Review procedure and reformulate prevention of repetitive complaint.

6.3 Reply to Customer complaints with action plan and target dates for achieving the same.

6.4 Communicate to customer on action taken on complaint.

DIRECT CUSTOMER FEEDBACK:

6.5 Receive information about direct customer satisfaction from HQ.

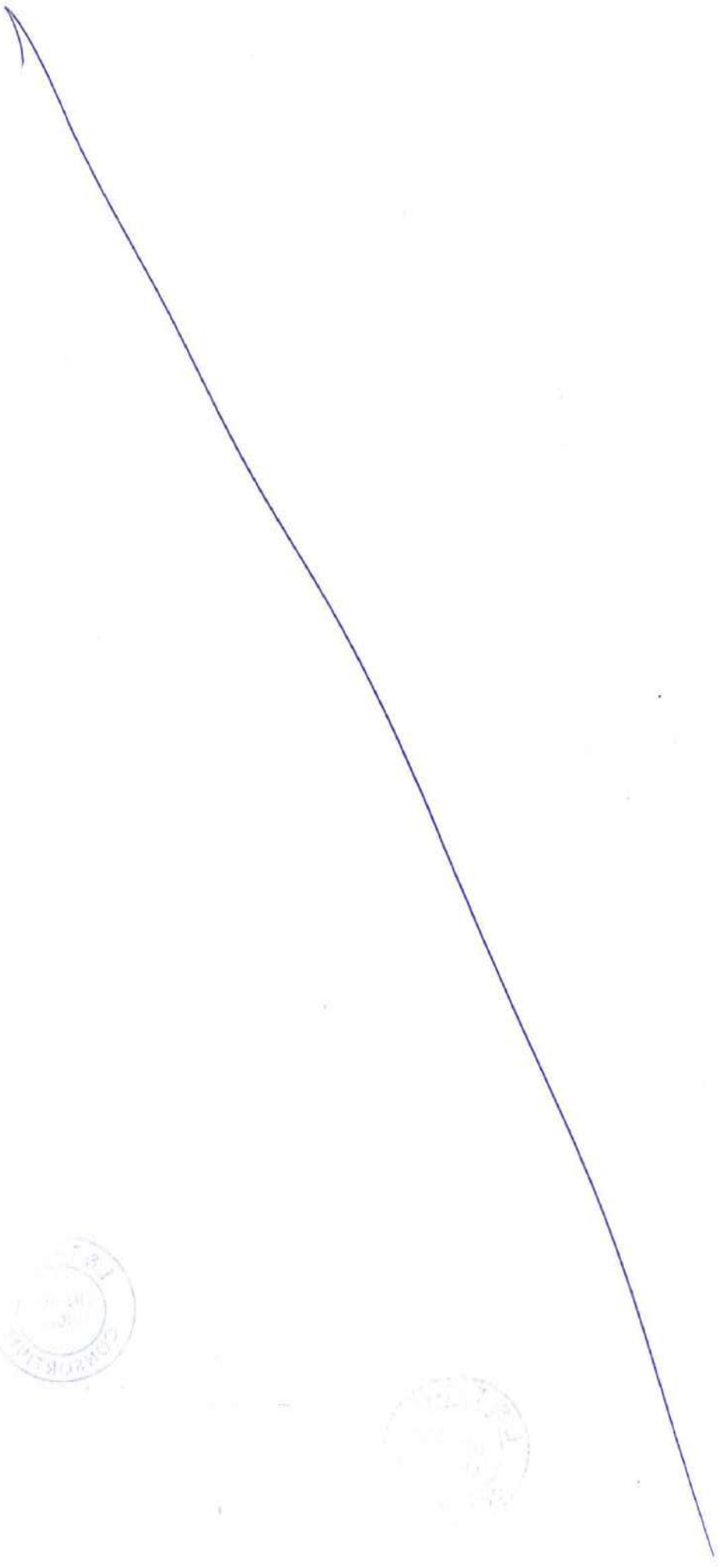
6.6 Prepare action plan on area of dissatisfaction with the consultation of all sections

6.7 Improve performance on area of dissatisfaction.

6.8 Inform HQ on area of action initiated.

7.0 RECORDS:

1. Customer complaint register – WP 15 F 01



Quality Assurance Plan

Reference ISO Clauses: 9.2 & 10.3

1. TITLE: Procedure for Internal Audits

2. PURPOSE: Monitor and check continuing suitability and effectiveness of the Quality management system

3. SCOPE: Project Quality Plan and Contract Documents

4. REFERENCE: Procedure for:

1. Document control
2. Management Review meeting
3. Corrective actions
4. Risks & Opportunities
5. Customer Feedback

5. RESPONSIBILITY: PRIMARY: QMS coordinator (SITE)

6. PROCEDURE:

6.1 Prepare Audit plan at site, covering all Inter-department audit once in Six months interval (Internal/HQ/External).

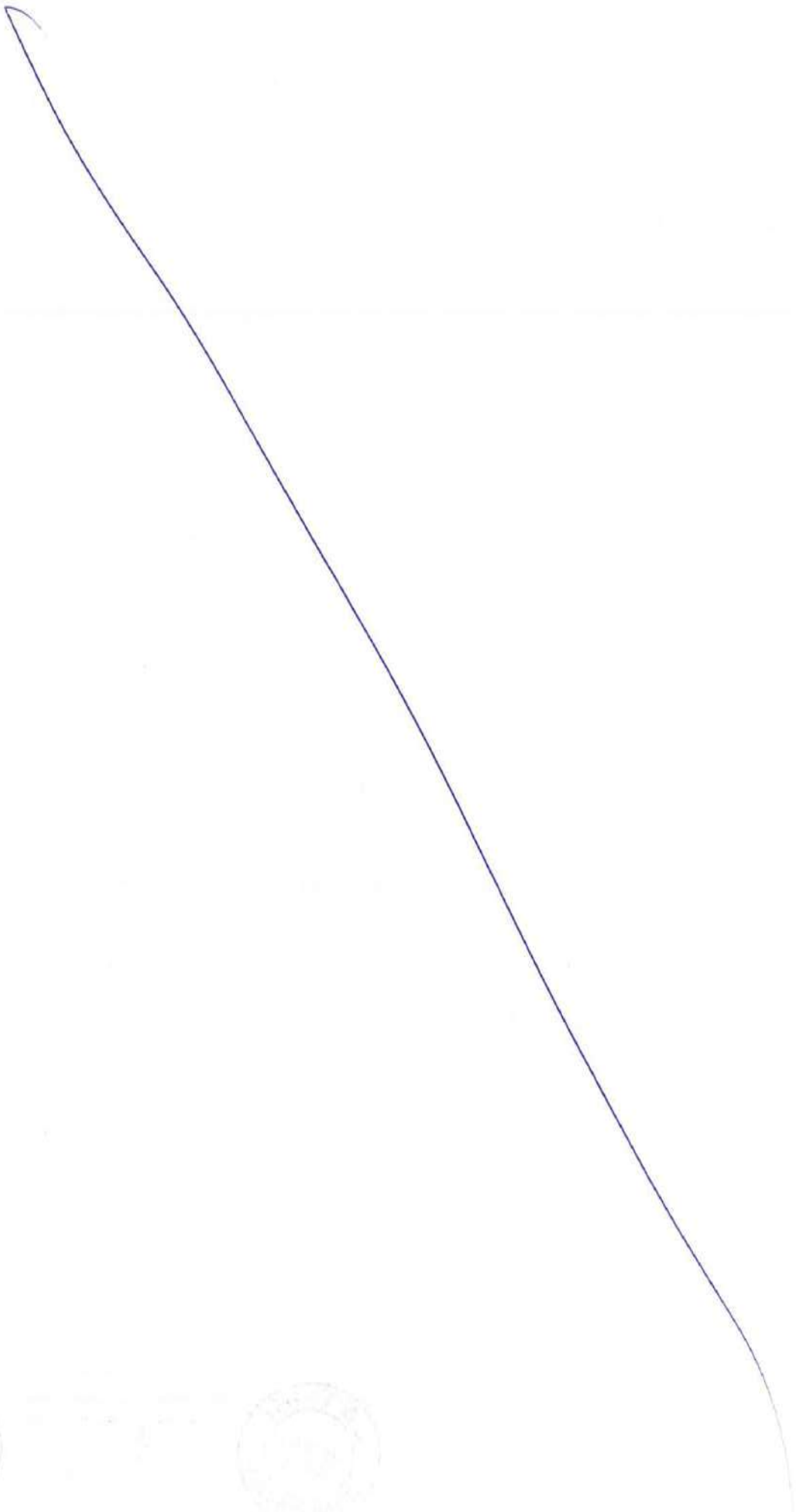
6.2 Intimate auditee of the concerned department well in advance.

6.3 Arrange Audit by trained auditor as identified on Scheduled date & time covering all the aspects of PQP including Product Quality checks. Check for pending NCRs if any, with reference to previous audits & reviews for root cause of the problem & corrective action if any for the same.

6.4 Auditor to raise NCR, in case of identification of non-conformity after verifying for objective evidence and seek acceptance of NCR by Auditee. Auditor shall give detailed reports on audit findings.

6.5 Follow-up with concerned departments for verification of actions taken on non-conformity & find root cause analysis to avoid repetition of non-conformity & to close NCR, and action taken for Audit findings as per report.

6.6 Summarise NCRs, Status, NCR Ageing analysis & Present for management review meeting at site level.



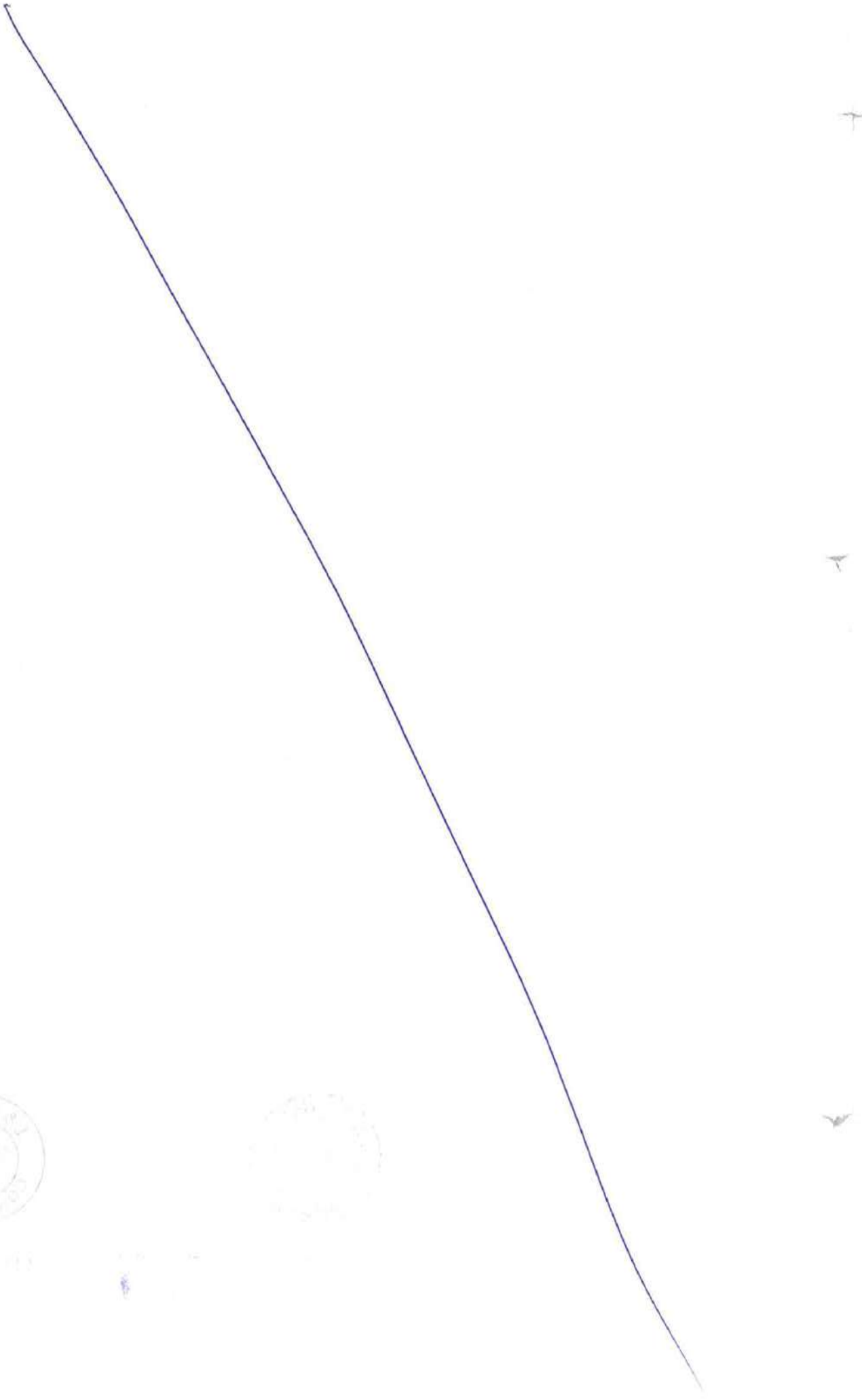
6.7 Update Audit Plan cum record based on findings and objective evidence obtained during audit.

6.8 Reschedule leftover audit (if any) to subsequent quarter.

6.9 Discuss audit findings in management review for the improvement in process / product quality and implement action plan as discussed.

7. Records

1.	Audit Calendar	- WP 16 F 01
2.	Audit Summary Report	- WP 16 F 02
3.	NCR	- GEN 10 F 03



Quality Assurance Plan

Reference ISO Clauses: 8.1, 8.4, 8.5, 8.7, 9.1 & 10.2

1. **TITLE:** Procedure for Inspection & Testing to control and deal with nonconforming products and prevent them from unintended use.

2. **PURPOSE:** Inspect & test all incoming materials and products & services under project scope as per ITP/QAP to control non-conforming products at all stages up to delivery and disposal of non-conformances if any appropriately.

3. **SCOPE:** Quality Management System (Project Quality Plan)

4. **REFERENCE: Procedure for:**
   1. Management review
   2. Risks & Opportunities
   3. Corrective actions

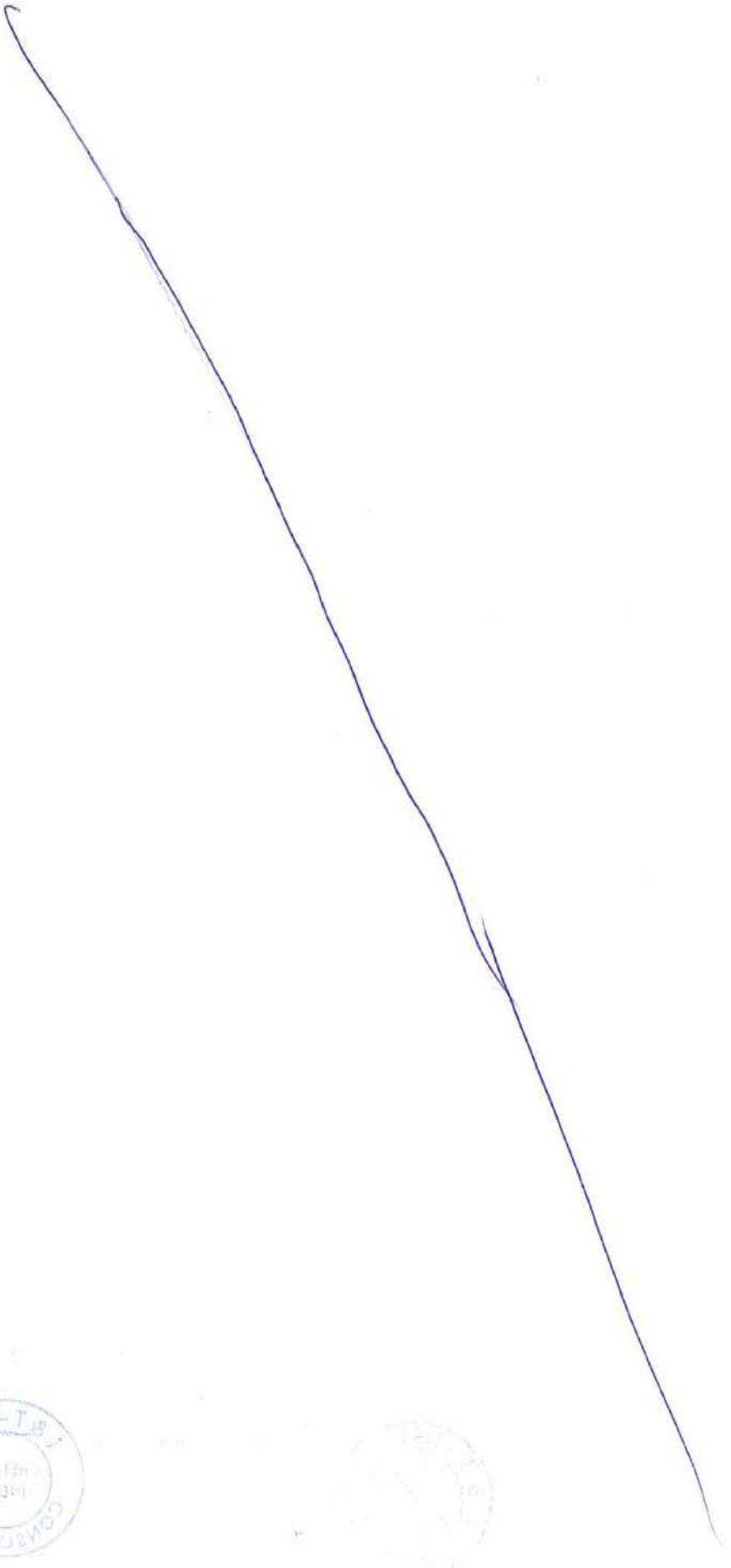
RESPONSIBILITY:

PRIMARY: QA/QC Engineer for section 6.1, Section heads for section 6.2

6. PROCEDURE:

6.1 INSPECTION & TESTING:

- Plan the characteristics of the raw material, process and product to be checked, frequency of check, method of check, sampling size (ITP/QAP) (Ref ITP 01)
- Plan stages of customer verification as per contract agreement. (ITP/QAP)
- Conduct inspection & tests as per plan and keep relevant records to demonstrate the conformance.
- Check the results against planned requirements. (ITP/QAP) Improve methodology or process and take necessary corrective action where planned results are not achieved
- Get approval of the competent authority and or the customer for acceptable minor deviations from the planned arrangements.
- Use calibrated equipment for measuring processes.
- After Completion of subsystems as per QAP the corresponding systems/subsystems shall be handed over to customer as per enclosed sample (Ref TOC 01)



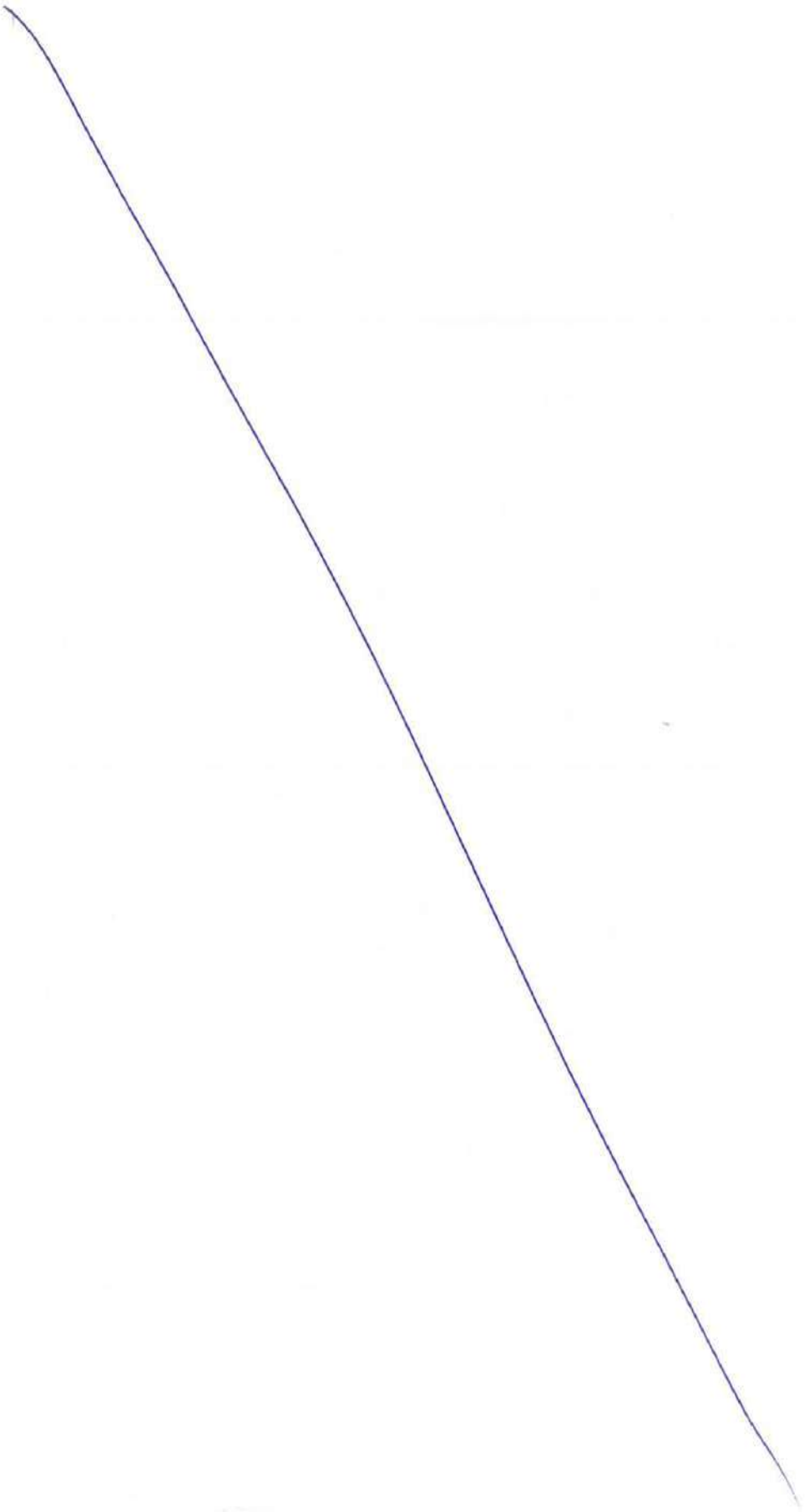
6.2 CONTROL OF NON-CONFORMING PRODUCT:

- Identify Non-conforming product / service found through
  - Customer complaints
  - Audits
  - Inspections
- Prepare action plan to remove the non-conformity.
  - By rectification /reworks/corrective action
  - By alternative use
  - By degrading
  - By scraping.

- Implement corrective action to eliminate the root cause of the non-conformity.
- Cases where non-conformity can be overcome by rework the same shall be done as per approved procedure and re-inspected to conform that the product meets the requirements.
- In cases of minor non conformity where product can be used for the process, which will not deviate from customer's specified requirement at final stage then no action shall be taken.
- If corrective action is not possible, identify such products and reject them. Rejected material or product shall be removed from the place of use to avoid unintended use.
- Cases where non-conformity is minor and will not affect the ultimate performance, take deviation from competent authority and / or customer for concession. Keep record of such products.
- Clearly identify & keep record of the above four categories of products to avoid unintended use of the non-conforming product
- Record the stages of detection and disposition of non-conformities to assist learning's and to provide data for analysis and improvement activities.
- Implement corrective action to eliminate the root cause of the non-conformity, wherever possible and verify the conformity to the requirements.

7. RECORDS:

1. Inspection & Test Plan / - WP 17 F 01



Quality Assurance Plan

Reference ISO Clauses: 9.1, 10.2 & 10.3

1. **TITLE: PROCEDURE FOR CORRECTIVE ACTION**

2. **PURPOSE:** Establish & maintain a procedure for corrective action (correcting & preventing the recurrence of non-conformities).

3. **SCOPE:** Quality Management System (Project Quality Plan) including product.

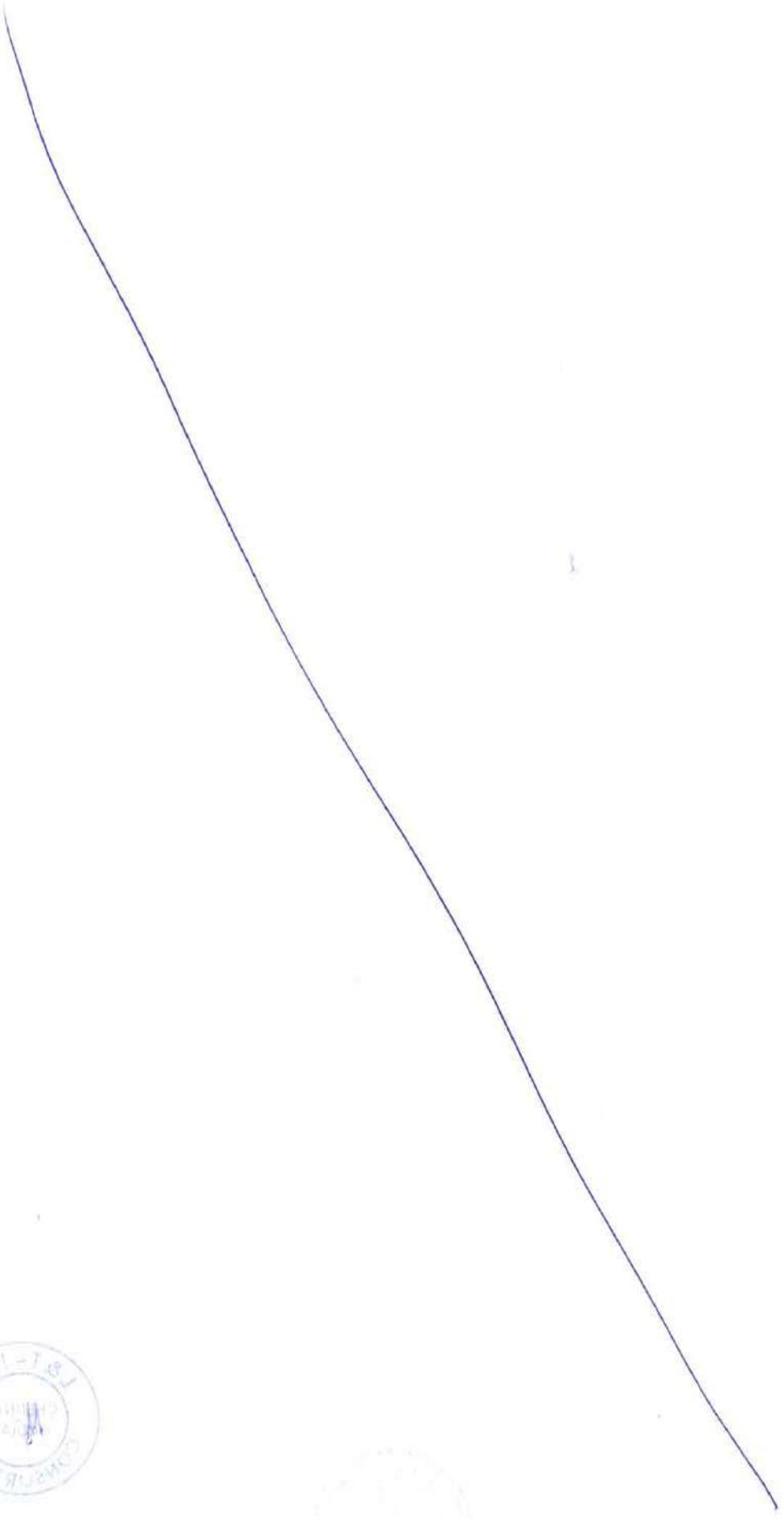
4. **REFERENCE: Procedure for:**
   a. Management review
   b. Internal audits
   c. Inspection testing & control of non-conforming products
   d. Risks & Opportunities
   e. Customer feedback

5. **RESPONSIBILITY: PRIMARY:** Respective Dept. Head, Auditee; **Secondary**: QMS Coordinator (Site), Project in-charge

6. **PROCEDURE:**

6.1 Non-conformities shall be detected by Auditors, customers, QA/QC engineer, QMS coordinator (Site), Project in-charge through

- Audits
  1. Inter departmental audits, HQ audit.
  2. Third party audit (Certification agency)
- Customer complaints
  9. Directly by site
  10. Through Cluster office / HQ
- Product Quality rating
- Inspections & tests
- Customer satisfaction
- Cost of poor quality
- Management Review
- Performance Reviews
  1. Process
  2. Product
  3. Business Results



6.2 Auditee shall find out root cause of nonconformity by analysing

- Where it happened
- What happened?
- How it happened.
- Why it happened

6.14 Corrective action shall be proposed , such as

- Re-work / rectification, re-inspection and acceptance if meeting the requirements.
- Alternate use
- Concession
- Rejection

6.15 Analyze the repetitive NCRs and nature of corrective actions taken to check the effectiveness of corrective action. Discuss with all concerned on corrective measures & effects. Review the following for improvement and avoiding its recurrences:

- Revision of working process or method.
- Revision of responsibilities/ Job Description
- Identification of Training need.
- Identification to additional staff requirement.
- Amendments to Documents.
- Change of Process to prevent harm to Environment
- Change of existing unsafe working practice and provide
- Safe working environment to personnel associated.

6.16 Identify the actions & responsibilities for implementation of counter measures.

6.17 Depending upon the nature of the root cause Project in charge shall assign a level of review when the root cause may manifest itself in the form of another potential problem.

6.18 Measure the effectiveness of the corrective action taken.

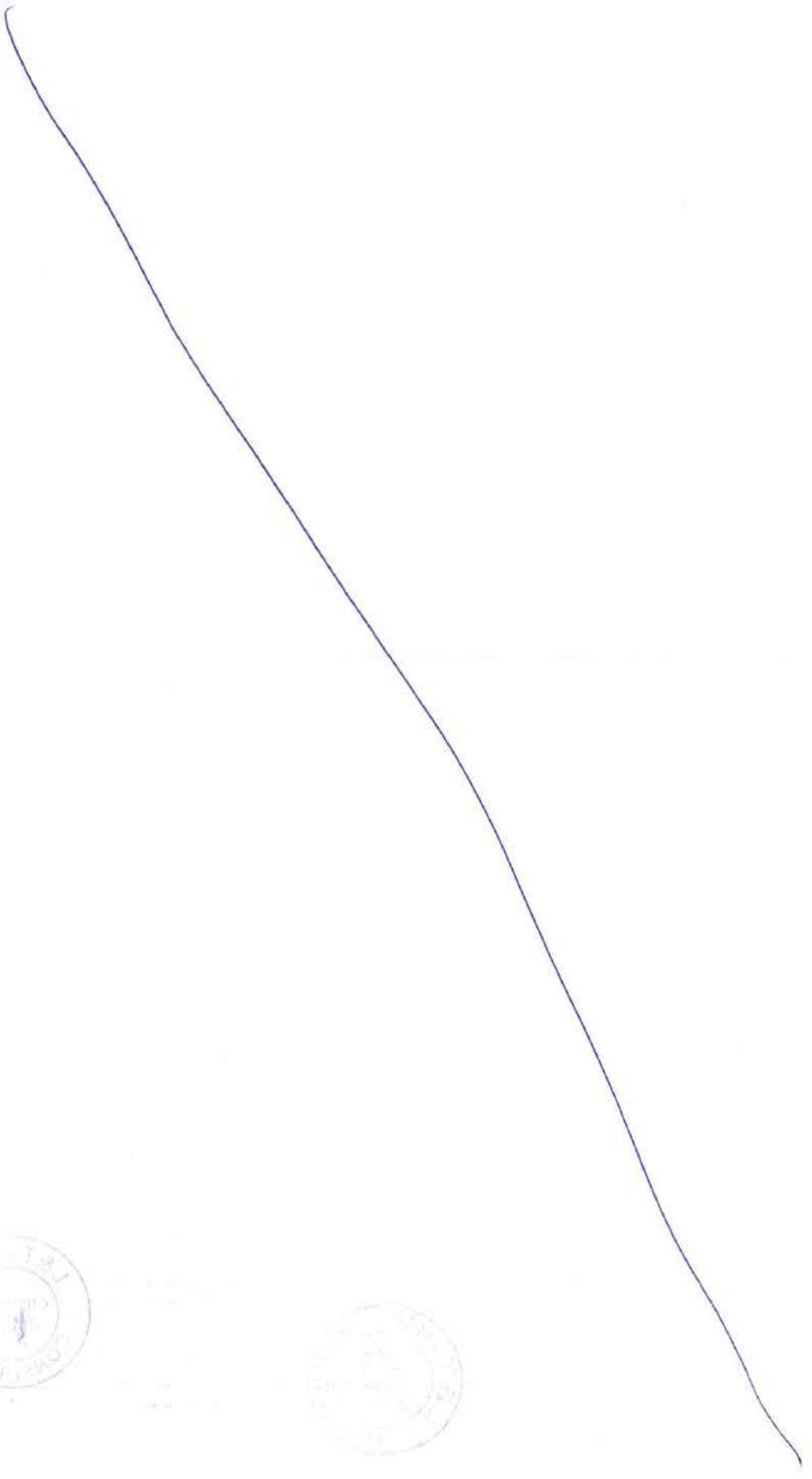
6.19 MR Site shall record the NCR and corrective action and discuss in MR meeting to prevent recurrence in other sections.

6.20 Record cost of quality /Rework under the assigned cost code by Section heads or his assigned engineer.

7.0 RECORDS:

7. Corrective action report

Reference ISO Clause: 9.1



Quality Assurance Plan

1. **TITLE: Procedure for analysis of data**

2. **PURPOSE:** Establish, implement & maintain a procedure to collect and analyze data to confirm the suitability and evaluate for continual improvement

3. **SCOPE:** Quality Management System (Project Quality Plan)

4. **REFERENCE: Procedure for:**
   a. Quality objectives
   b. Internal audits
   c. Corrective actions
   d. Risks & Opportunities
   e. Customer feedback

5. **RESPONSIBILITY: PRIMARY:** All section heads

6. **PROCEDURE:**

6.1 Collect and analyse data's from
- Internal audits
- Management review meetings

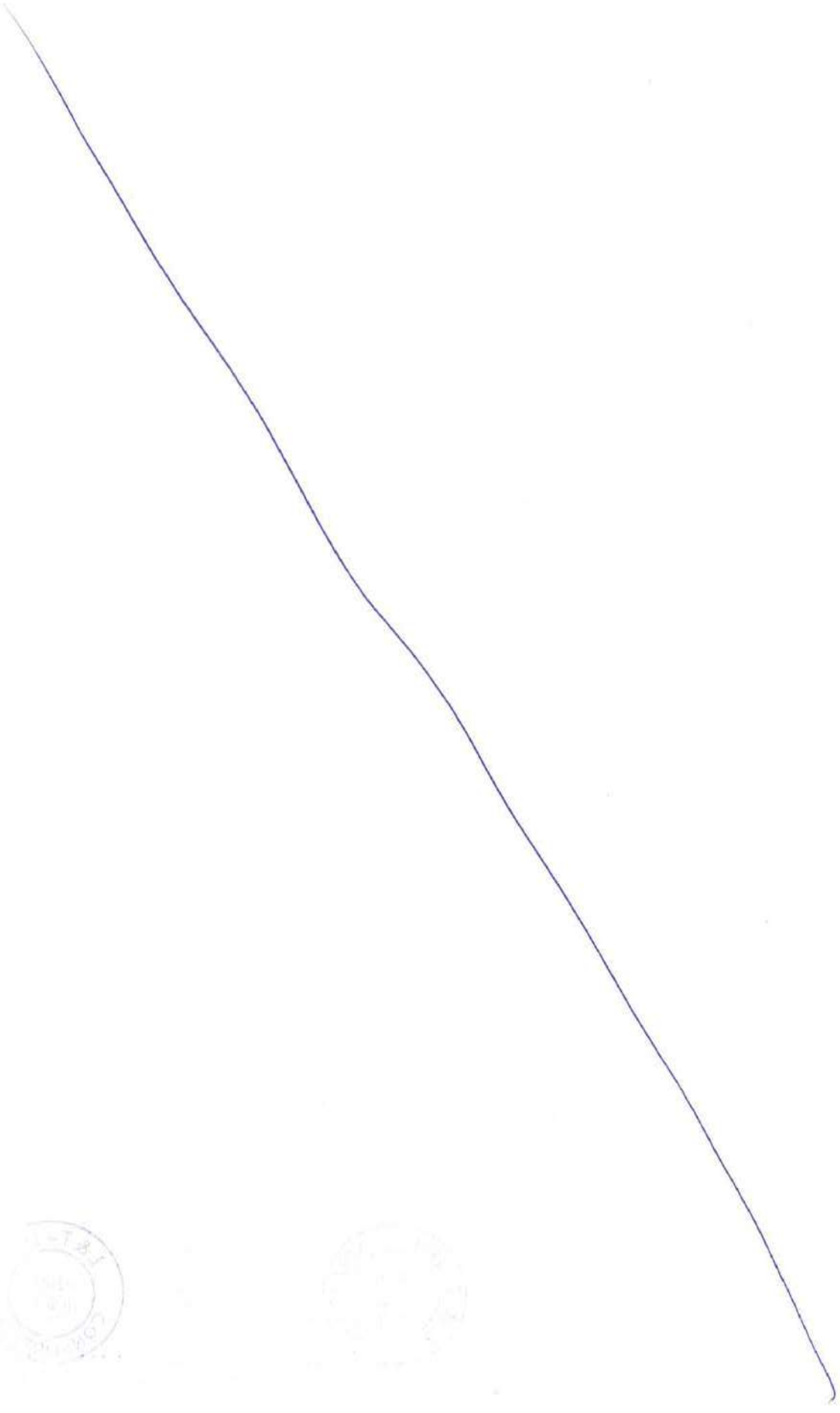
6.2 Collate information regarding to
- Customer satisfaction
- Conformity of product
- Trends of process & products
- Opportunities for preventive action
- Customer complaint
- Trends of NCRs observed in system implementation.

6.3 Analyse & Prepare road map for Improvement required in the data collected in step 2 for each of points.

6.4 Implement action as per the road map prepared.

6.5 Use Statistical techniques to monitor planned results such as bar chart, linear chart, Standard deviation etc., for the planning & other functional area as applicable.

7. **RECORDS:**



L&T - IHI

Mumbai Trans Harbour Link Project (Package-1)

IFB No: MMRDA/ENG1/000752

Quality Assurance Plan

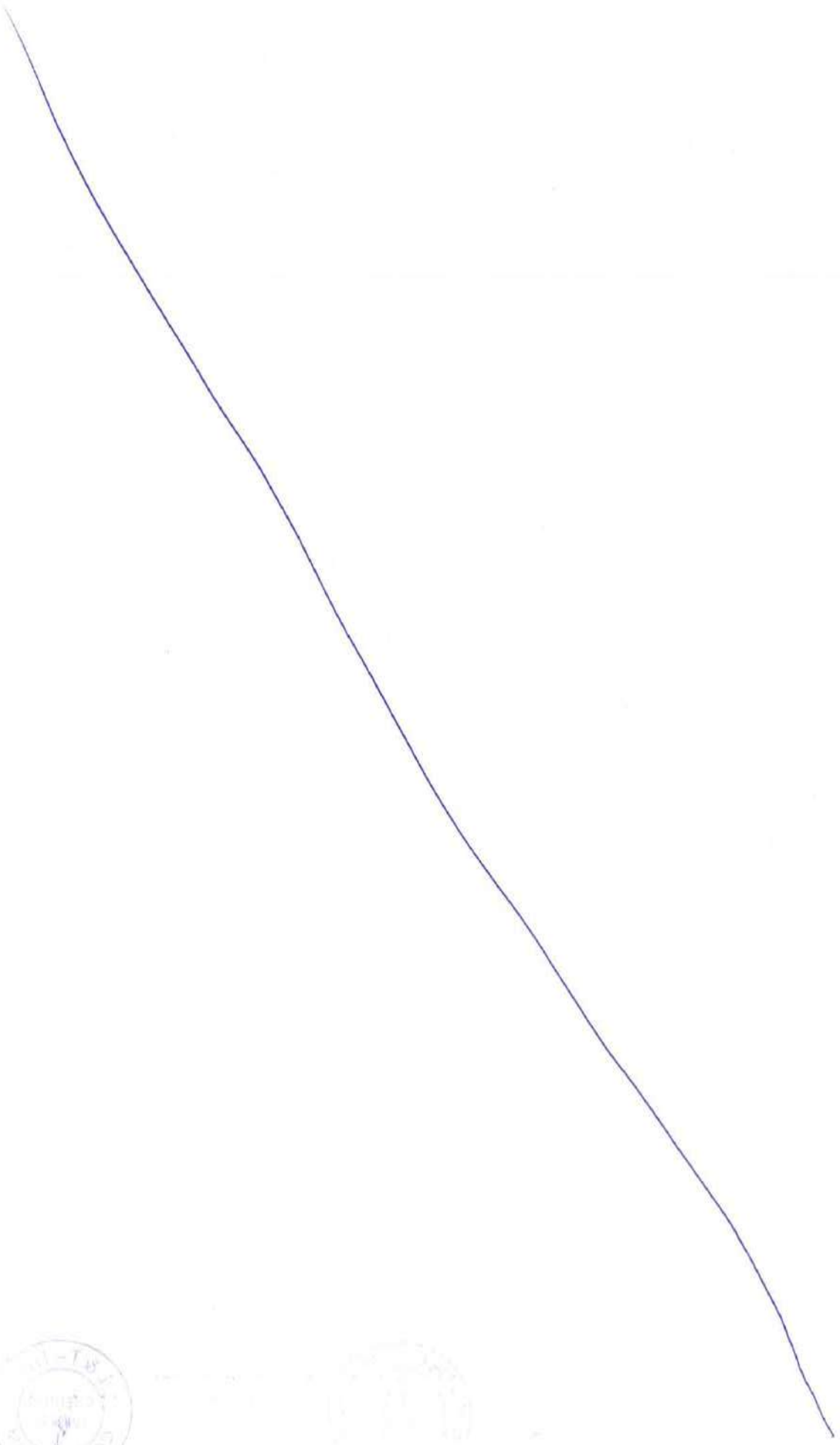
SL. No	Functional Area	Linked Procedure	Scope	Techniques used	Responsibility	Record	Record Distribution
1	Project progress • Plan Vs Actual • JCR Vs ACE • Invoicing • Milestone Events • Subcontractor ratins	PQP WP 07	All Parameter for work status indicators	Bar charts, Gantt Chart / Linear chart	Planning	Monthly progress report	Project in-charge, Cluster Head / HQ
2	Complaints & NCs • Customer Complaints • NCRs • CSR for each parameter • Cost of rework	PQP WP 15	All complaints and non compliances	Bar Charts	Planing Engineer	Monthly Quality report	HQ
3	Inspection and testing • Cube test	PQP WP17	To establish degree of	Standard deviation, Control	QC Engineer	Monthly report	Project in-charge

Sample functions

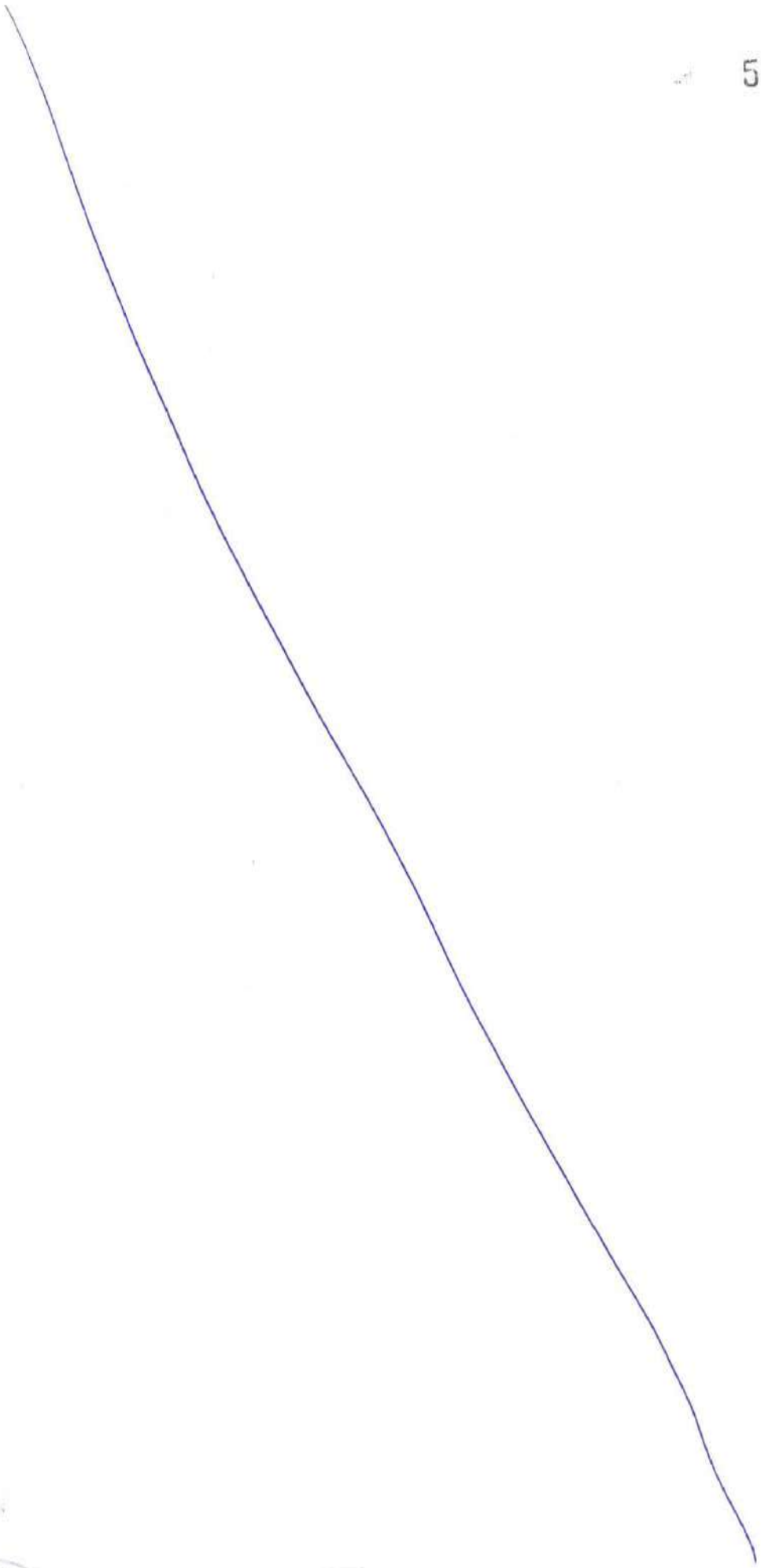
MMRDA
MUMBAI METROPOLITAN REGION DEVELOPMENT AUTHORITY

L&T - IHI CONSORTIUM CHENNAI (INDIA)

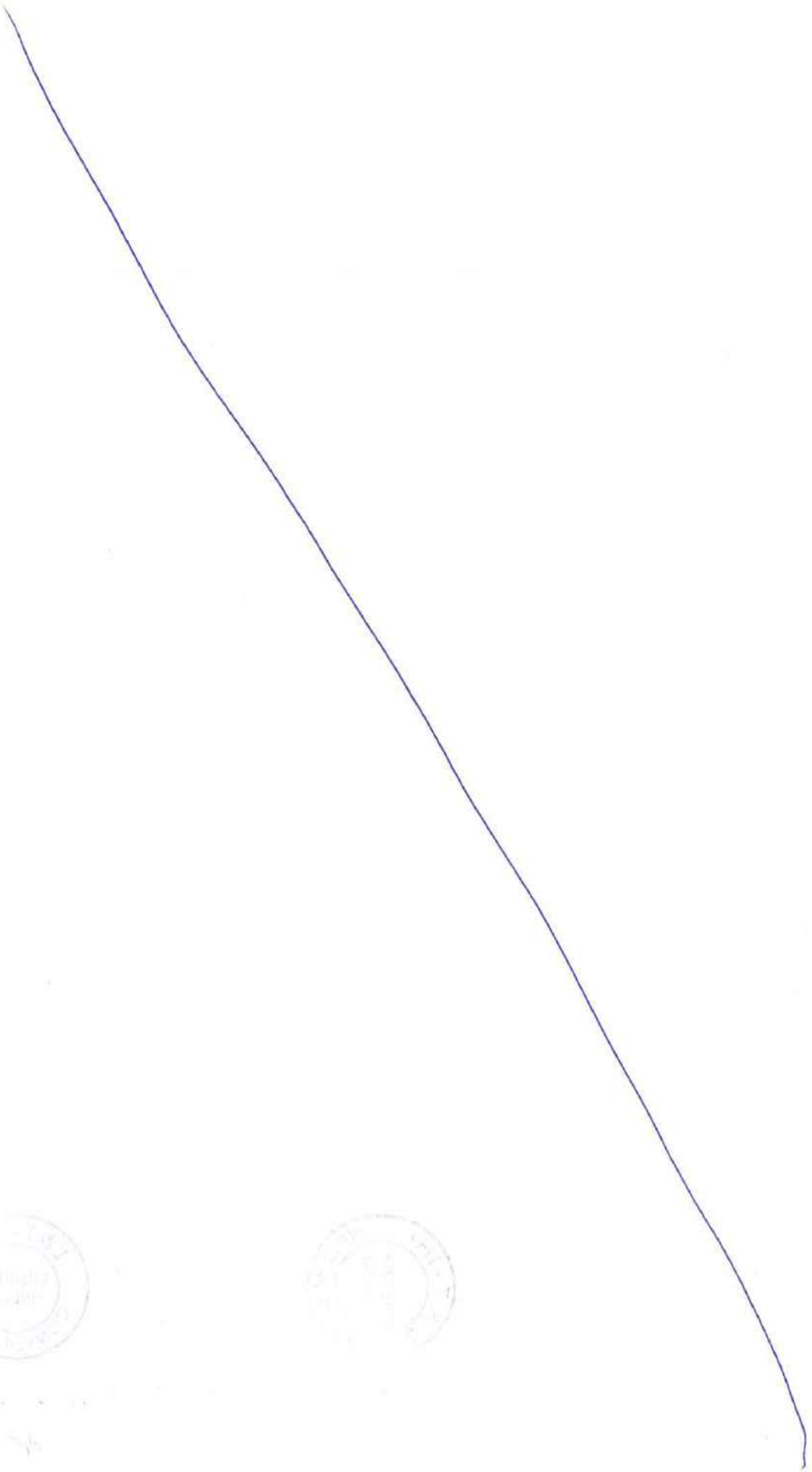
L&T - IHI CONSORTIUM CHENNAI (INDIA)



	results • NDT test Results • Concreting, soil asphalting mfg. • Welders Performance, • Others as applicable to Disciplines.		control And monitoring performance	charts, Linear charts			
4	Productivity • Staff • Labour • P&M	PQP WP 09 PQP WP 07-1	All Activities	Bar graph, linear charts	Panning	Monthly report	Project in-charge
5	Materials • Supplier rating • Material acceptance • Reconciliati	PQP WP 10	All procurement	Acceptance at first instance, delivery Vs Schedule	Procurement	Monthly report	Project in-charge



	on & wastage			linear charts			
6	Training & Orientation • Staff training • QMS Orientation	PQP WP 06	All training	Linear charts	Department Heads	Training Schedule and Records	Project in-charge



Quality Assurance Plan

Interface Management

1. INTRODUCTION

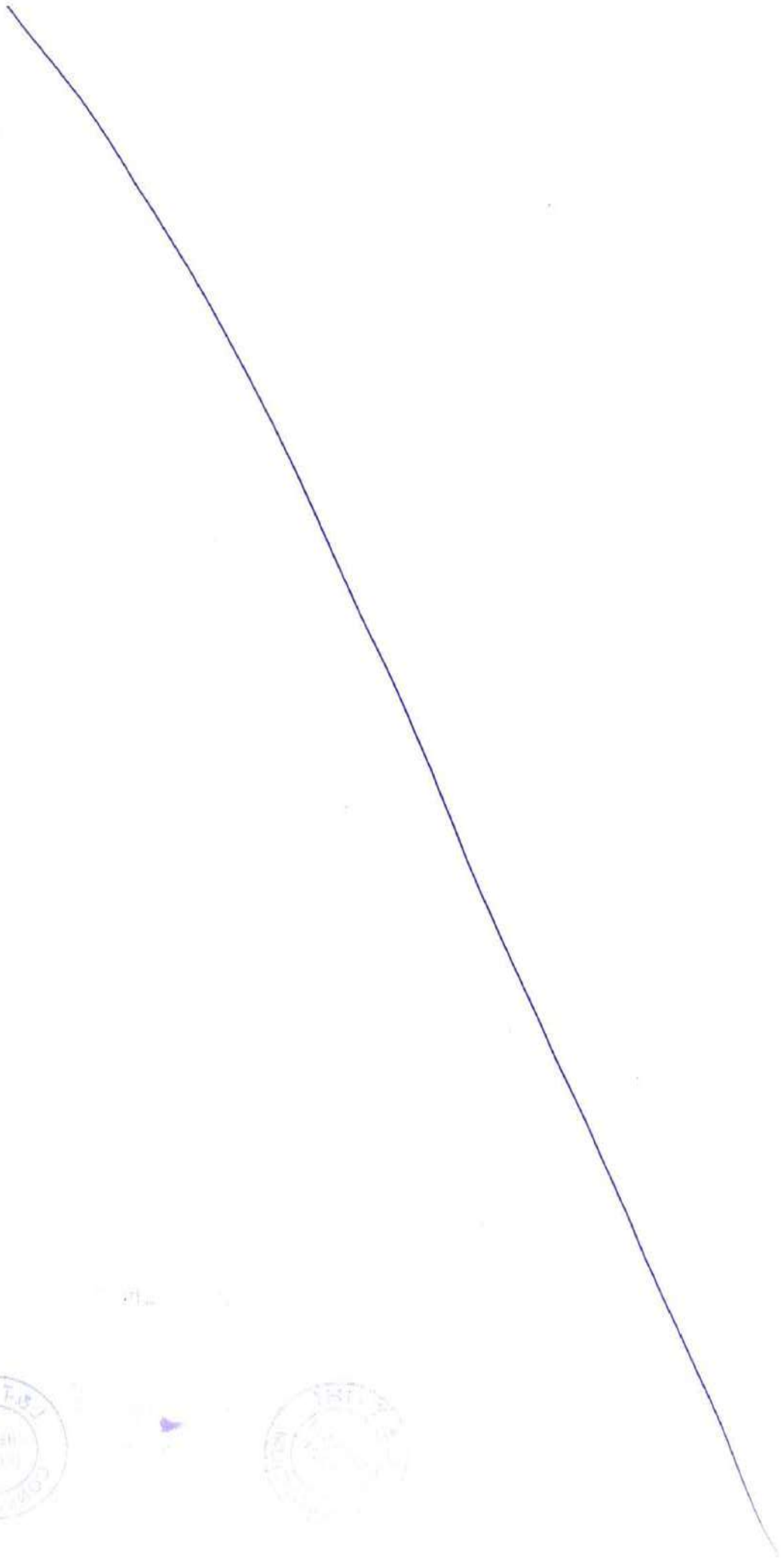
1.1 Objective of Interface Management Plan:

The objective of this document is to identify activities of _____contractor as well as those of other contractors and authorities which are required to be interfaced. _____ contractor will interface and liaise with such contractors and agencies to ensure effective co-ordination on all aspects of balance works of design, construction, installations and testing of the works so that works of _____ contractor and that of other contractors can be progressed as per laid down schedule and targets.
The aim of this interface management plan is to ensure that all interface issues are resolved satisfactorily by maintaining close interface with the designers & other concerned contractors so that the problems anticipated / faced during design/design review, procurement and execution at site are communicated at the appropriate time. Periodical interface meetings shall be coordinated to arrive at logical and expeditious solutions, to ensure smooth progress of physical works & realization of the scheduled dates for completion of works.

This Interface Management Plan (IMP) defines the organizational structures and procedures to be used by contractor _____ in order to develop and maintain the detailed interface requirements between contractor _____ and the distinct interface partners and to test the interfaces. The performance of the Interface Management Plan will yield a number of interface specifications, which are agreed on by the respective partners and which provide framework such that the interface partners can proceed with their work independent of each other. In addition a survey on the interface partners is provided

1.2 Scope and Responsibilities :

The Contractor _____ shall co-ordinate with the interfacing contractors and may be required to attend meetings on issues appertaining to Government authorities and utility agencies regarding the services/facilities to be provided by them for the project.

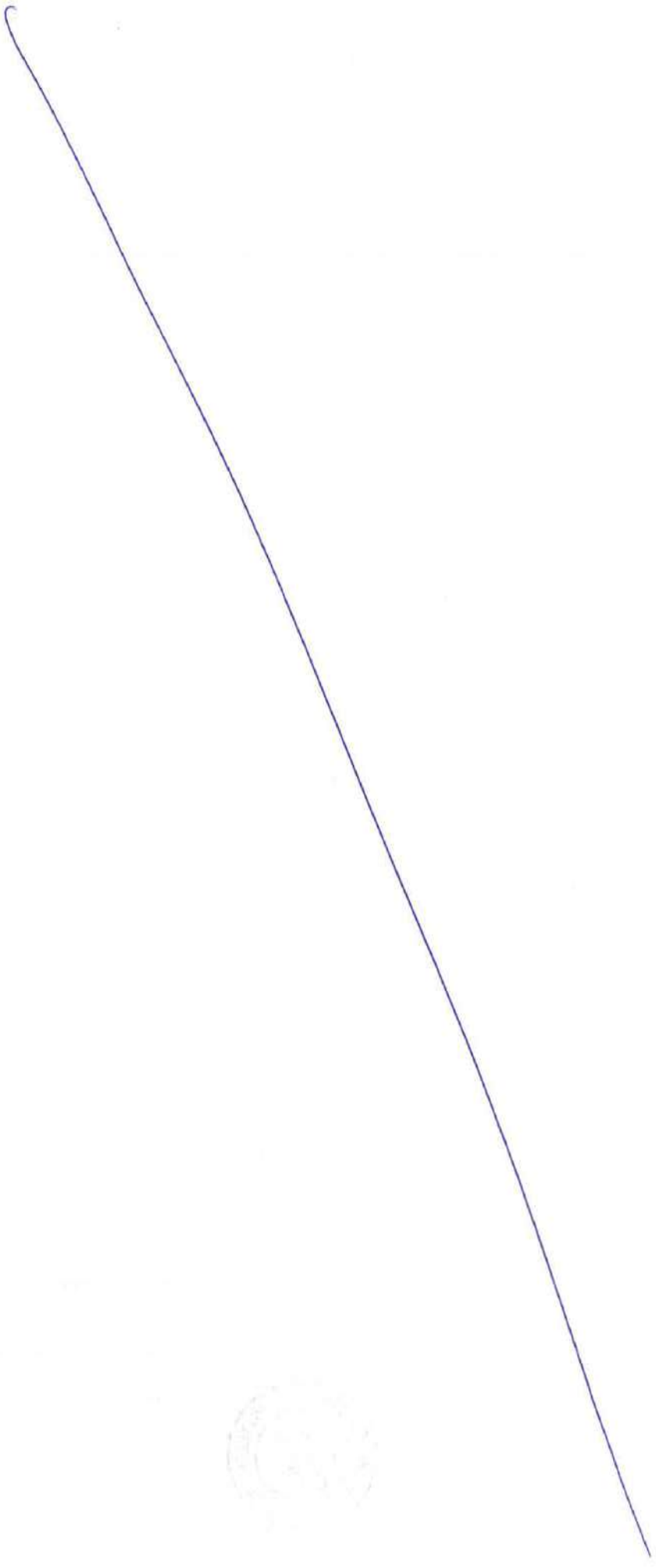


Quality Assurance Plan

We will ensure that the work of all Interfacing Contractors can be carried out in accordance with the Interface Management Plan prepared by the Contractor.

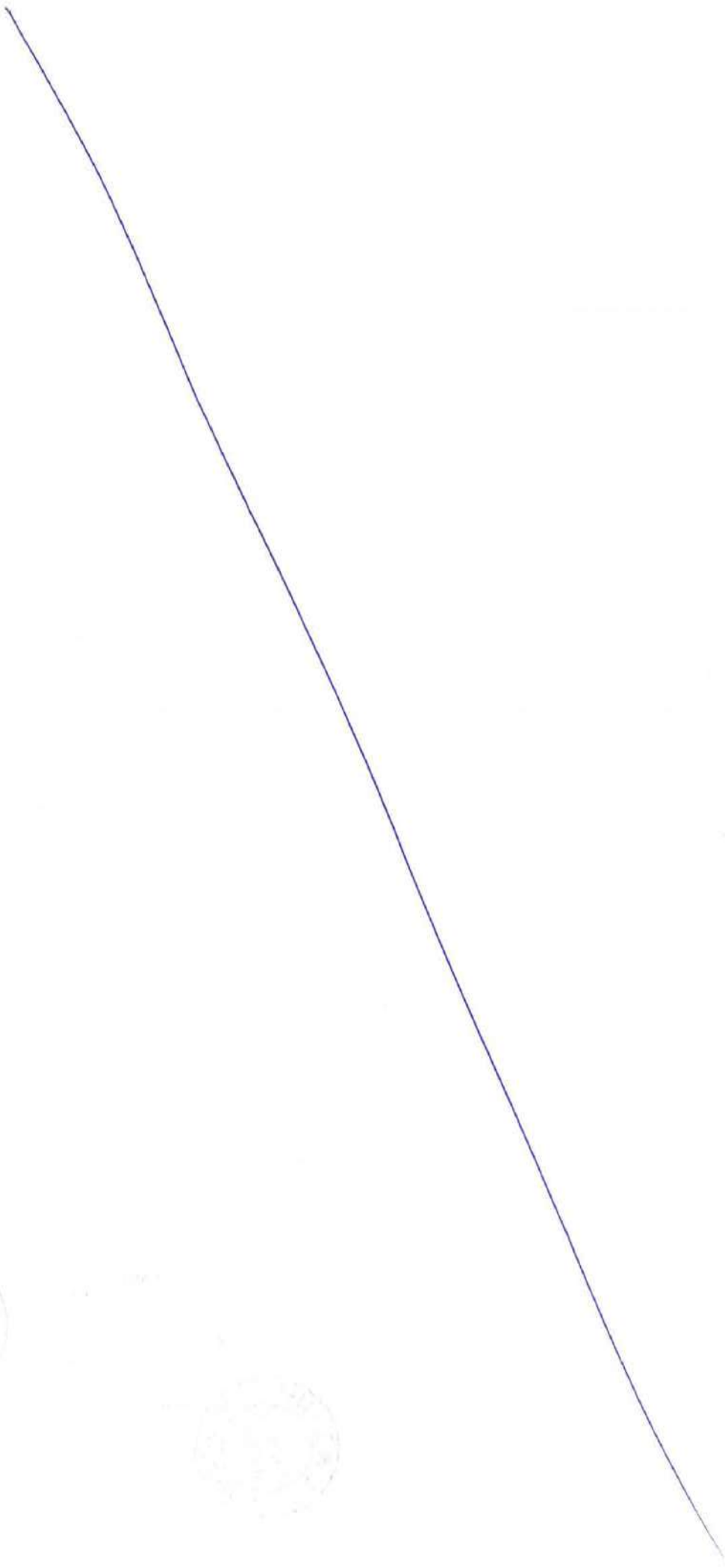
The Contractor _____ shall, at his own cost, provide all attendance on and co-ordination with Interfacing Contractors. The following items are not a comprehensive or exhaustive list of the co- ordination or interface attendance items to be provided for the Interfacing Contractors' use, but are intended to provide an outline of the content of amenities, services and facilities for which the Contractor _____ is responsible:

- Chief Interface coordinator shall be Single point of contact for meetings, actions, planning, scheduling and coordinating.
- Site access:
- We shall co-ordinate with the Interfacing Contractors and provide access and use of temporary access roads to and from and within the Site. We shall co-ordinate all vehicle movements, deliveries and other activities with the Interfacing Contractors so as to ensure conflicts of use will be controlled on and around the Site
- Storage and Accommodation area:
- The Interfacing Contractors will require limited temporary site accommodation and storage areas. We shall agree with the Interfacing Contractors access and areas, for storage and temporary site accommodation prior to their commencing work on Site.
- Work space requirement and sequence of Works
- Shared use of Contractor's scaffold
- The Contractor _____ shall co-ordinate with the Interfacing Contractors and provide shared access of his erected scaffolding, ladders and hoists should they be available at the time the Interfacing Contractor requires to use them. Notwithstanding this requirement, We shall at all times remain responsible
- for the management of safety and the maintenance of such scaffolding, ladders and landings.
- _____ contractor will not be required to adapt or erect access scaffolds specifically for the use of Interfacing Contractors.
- If the Interfacing Contractor erects and uses his own scaffold he will be required to adhere to the



- _____ contractor safety rules and access routing for equipment and materials. Contractor _____ shall ensure that all scaffolds of Interfacing Contractors are erected in a are subject to permits for use issued by the Contractor.
- Setting out control points
- Access Openings
- Contractor _____ will form all penetrations and delivery openings and subsequently close them (either temporary or permanent) for access to rooms or areas for the delivery of equipment and materials
  The Contractor _____ will be required to install all temporary and permanent lifting hooks and beams shown Temporary lighting requirements 100 lux minimum.
- Temporary power and water supplies have to be provided at agreed locations around the Site for the Interfacing Contractors use
  Water tightness. All rooms and areas handed over to Interfacing Contractors shall be in a watertight condition and maintained as such.
- Ensure all electrical supplies both temporary and permanent have the correct testing and commissioning certification
- Appropriate protection to finishes, walls, floors, ceilings and equipment using polythene,hardboard, steel plates etc
- Fire fighting and supply and maintenance of fire extinguishing equipment and devices pursuant to the _____ contractor obligations
  Construction interface co-ordination management of penetrations in structures, embedded and cast-in items, etc.
- _____ contractor shall provide, operate and maintain all necessary temporary drainage, sumps, silt traps and sump pumps to collect and dispose of wastewater from Interfacing Contractors construction processes including installation, testing and commissioning activities.
- Sanitation facilities
- _____ contractor shall provide all sanitation facilities and the disposal of waste. No unauthorized sanitation facility will be allowed on the Site.
- Making good and fire stopping of penetrations

Lifting apparatus and hoists:



_____ contractor will be required to install all temporary and permanent lifting hooks and beams shown on the drawings and the Specification required for installation and/or maintenance purposes. _____ contractor will be responsible for the testing and labeling of all apparatus. _____ contractor will be required to make available any lifting or hoist apparatus on Site as required by the Interfacing Contractor at agreed times and duration for their use. _____ contractor shall be responsible for the maintenance testing and operational management of hoists.

- Health and Welfare Facilities

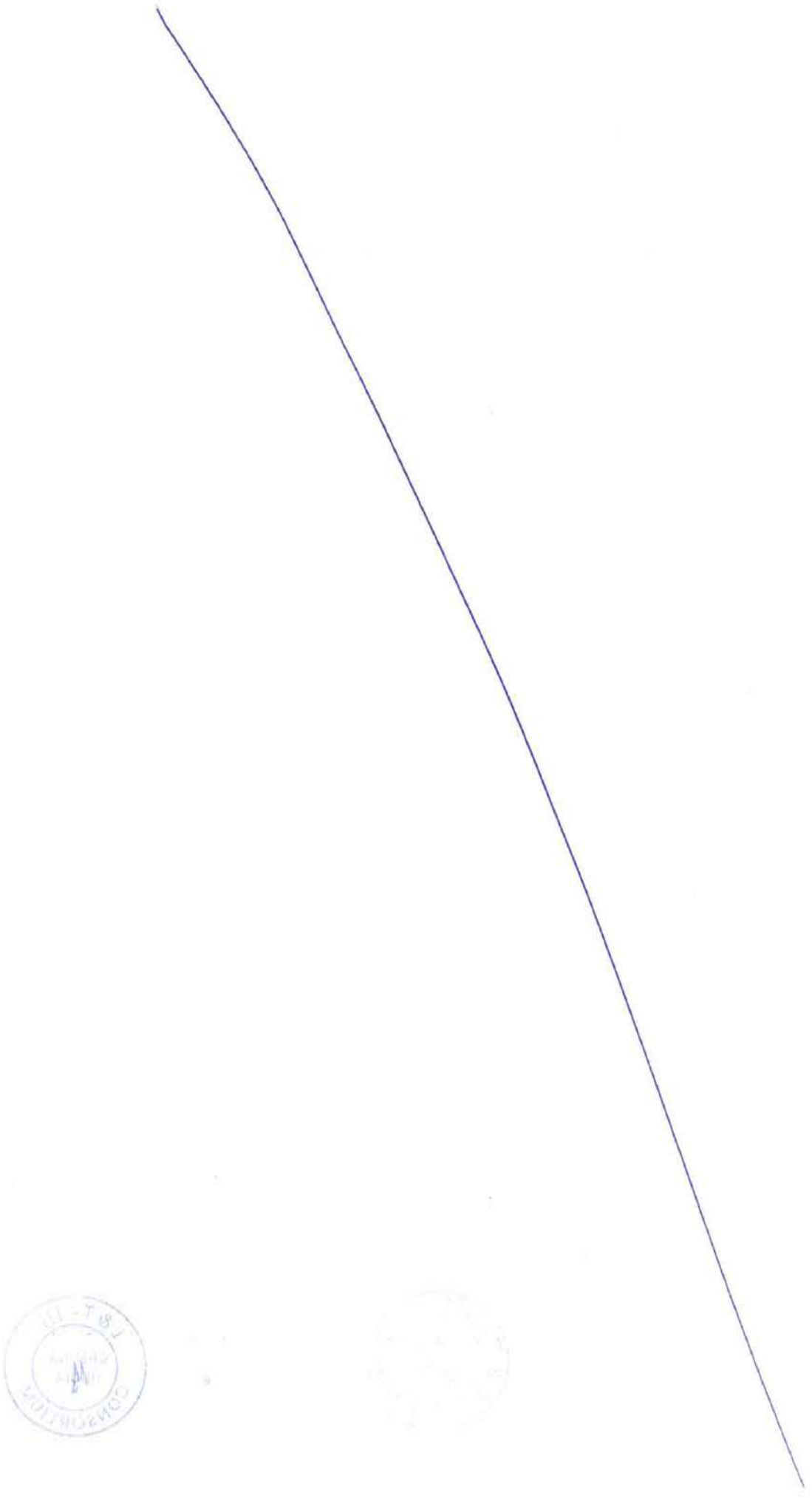
1.3 Overview of _____ Interfaces

S.	Interface Scope	External Entities
1		
2		
3		
4		
5		

1.5 DEFINITIONS:

1.5.1 Chief Interface Coordinator means a suitably qualified person, who is the Team Leader of contractor's Interface Management Team, responsible for administrating, monitoring, managing, supervising and resolving all interface issues between Interfacing Contractors for the _____project

1.5.2 Combined Services Drawings (CSD) means those drawings produced by contractor _____, showing the locations, sizes and details of all of the equipment, cable containment, pipes, etc. These drawings are to be used to enable all equipment, pipes, cables, etc.. to be installed without conflict and to enable future changes or modifications to be performed without impacting the existing installation



1.5.3 Interface means the region of interaction across the common boundary between two adjacent but separately managed and controlled parts of the Project. The coordination and management of the interaction regions is necessary to ensure that the overall scope and definition of the Project works is complete and seamless across all such boundaries.

1.5.4 Interfacing Contractors means any of the following whose activities or the works they are engaged to carry out in any way or at any time affect or are affected by the Works:

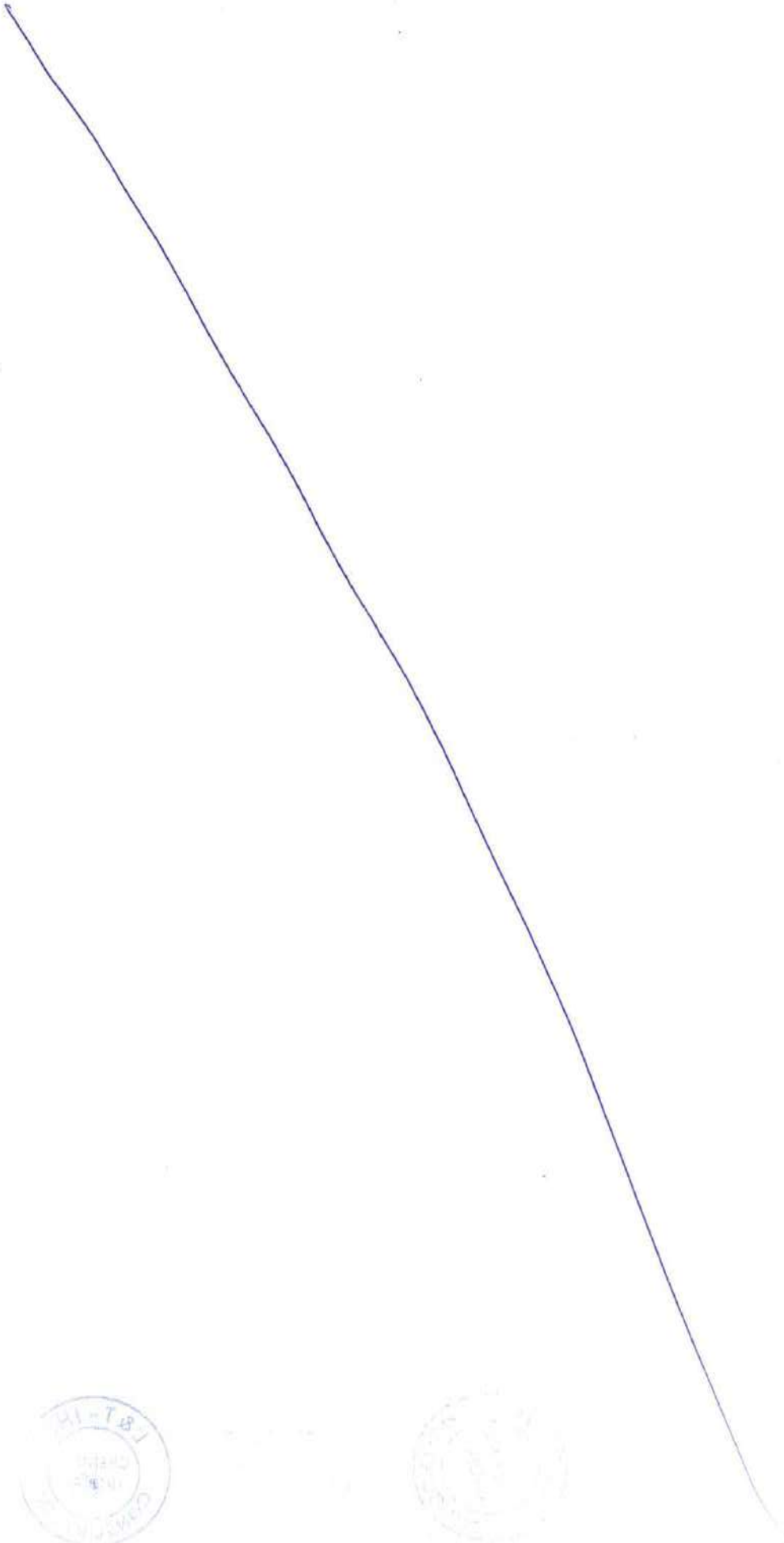
a) Project Contractors and design or specialist consultants engaged on the Project from time to time by the Employer, the Government of Republic of India, or the utility providers;
b) Utility providers;
c) Developers or franchisees appointed on the Project from time to time by the Employer;
d) subcontractors of any tier of the contractors within category (a) above, and contractors and subcontractors of any tier of utility providers, developers and franchisees within categories (b) and (c) above;

provided that the definition shall exclude the Contractor and his subcontractors of any tier in relation to the Works and in any other capacity which would otherwise fall within categories (a) to (d) above in relation to other works

1.5.5 Interface Coordination Sheet (ICS) means a document produced by us which defines the integration and interfaces between his contract and the Interfacing Contractors employed on the Project.

1.5.6 Interface Management Programme (IMPG) means the programme produced by the Contractor, developed and updated on a quarterly basis, which describes the sequence and timing of each of the Interfacing Contractors' scope of work, and clearly describes dependencies between his Works and the work of the Interfacing Contractors.

1.5.7 Interface Management Plan (IMP) means the Report prepared by the Contractor, developed and updated on a quarterly basis that provides a clear description of his Interfaces both sequentially and technically as specified in the Contract. The report Employer's Representative's Notice of No Objection.



1.5.8 Interface Specification (IS) means the specification document developed by the Lead Contractor for the interfacing part of his project on the basis of, and by integrating into his design, the information provided by the Interfacing Contractor/s, in accordance with the interface agreements as contained in the ICS. The Interface specification needs to be agreed upon by both the Lead Contractor and the Interfacing Contractor/s, before it is submitted to the Employer's Representative (ER) for Notice of No Objection (NONO).

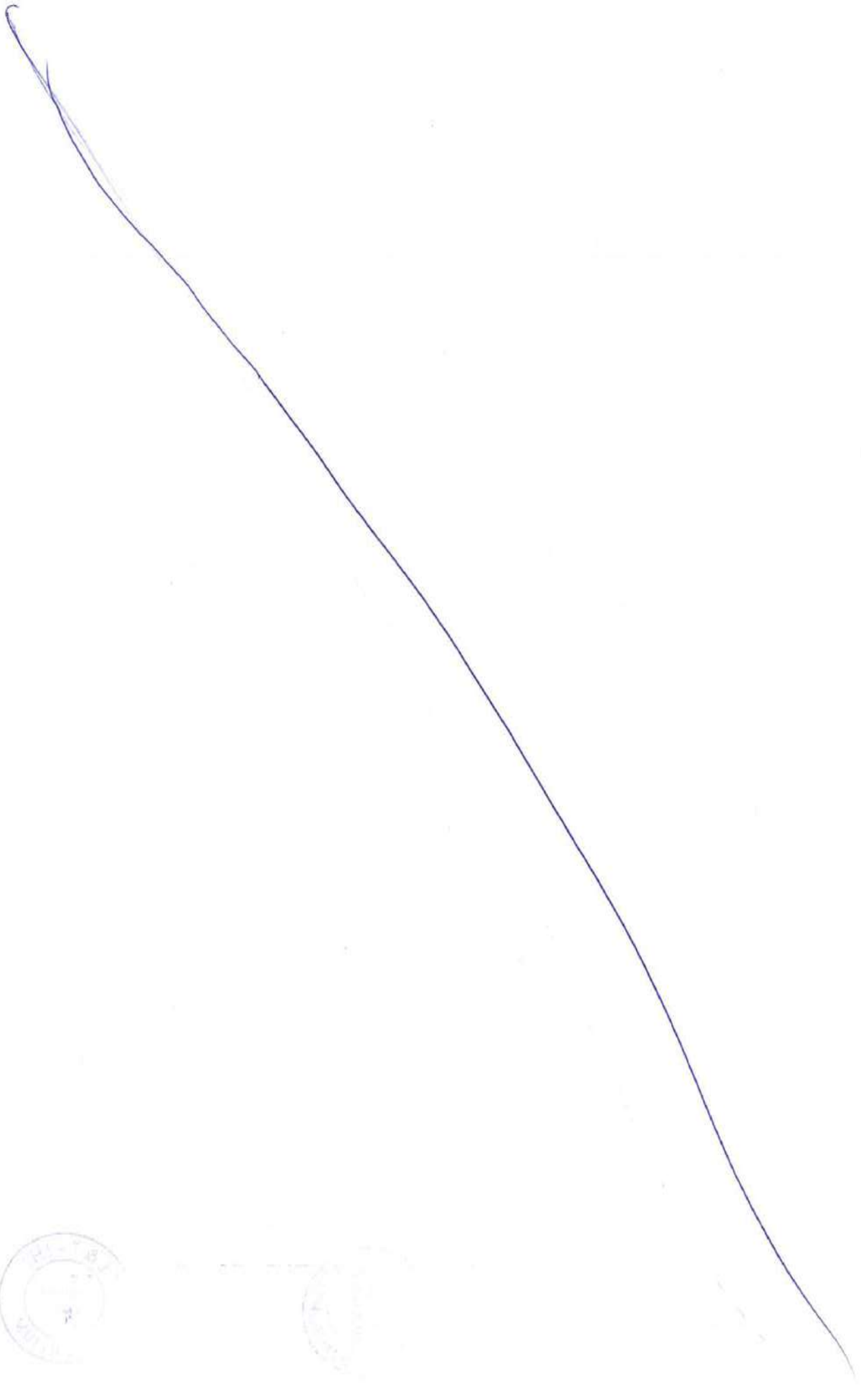
1.5.9 Master Interface Matrix (MIM) means the document developed by the Employer's Representative, which may be updated, and/or expanded to include additional Interfacing Contractors, by the Employer's Representative as the Project progresses. The purpose of the Master Interface Matrix is to allocate which Interfacing Contractors are the lead party(s) for each contract.

1.5.10 Structural, Electrical and Mechanical Drawings (SEM) means those drawings produced by the Contractor, showing the locations, sizes and details for all structural openings, plinths, embedment's, sumps, floor chases, etc... Required for the installation of all equipment, cable trays, pipes, etc...

1.5.11 Zone of Interface means where two or more components of the railway provided by two or more Interfacing Contractors combine to provide a single element.

1.6 Document References

No	Title	Document no
[1]	Contract – _____	**Volume-1 Employers Requirement Appendix 19**
[2]	Project Management Plan	
[3]		
[4]		
[5]		
[6]		
[7]		
[8]		



2 Interface Management system:

We establish and maintain an Interface Management System to identify, control and monitor the interfaces of the Contract, which shall include, but not be restricted to, the following:

- Establishment and maintenance of an Interface Management Team suitably qualified and experienced in co-ordination and interface management.
- Provision, as one of his Key Personnel, of a Chief Interface Co-coordinator, to head the Interface
- Management Team, suitably qualified and experienced with the responsibility, experience and authority to resolve interface matters in accordance with the Contract. The Chief Interface Co-coordinator will develop a monitoring and reporting procedure to be implemented by his team for the duration of the Contract.

a) Monitoring of Interface process and data flow shall be ensured by

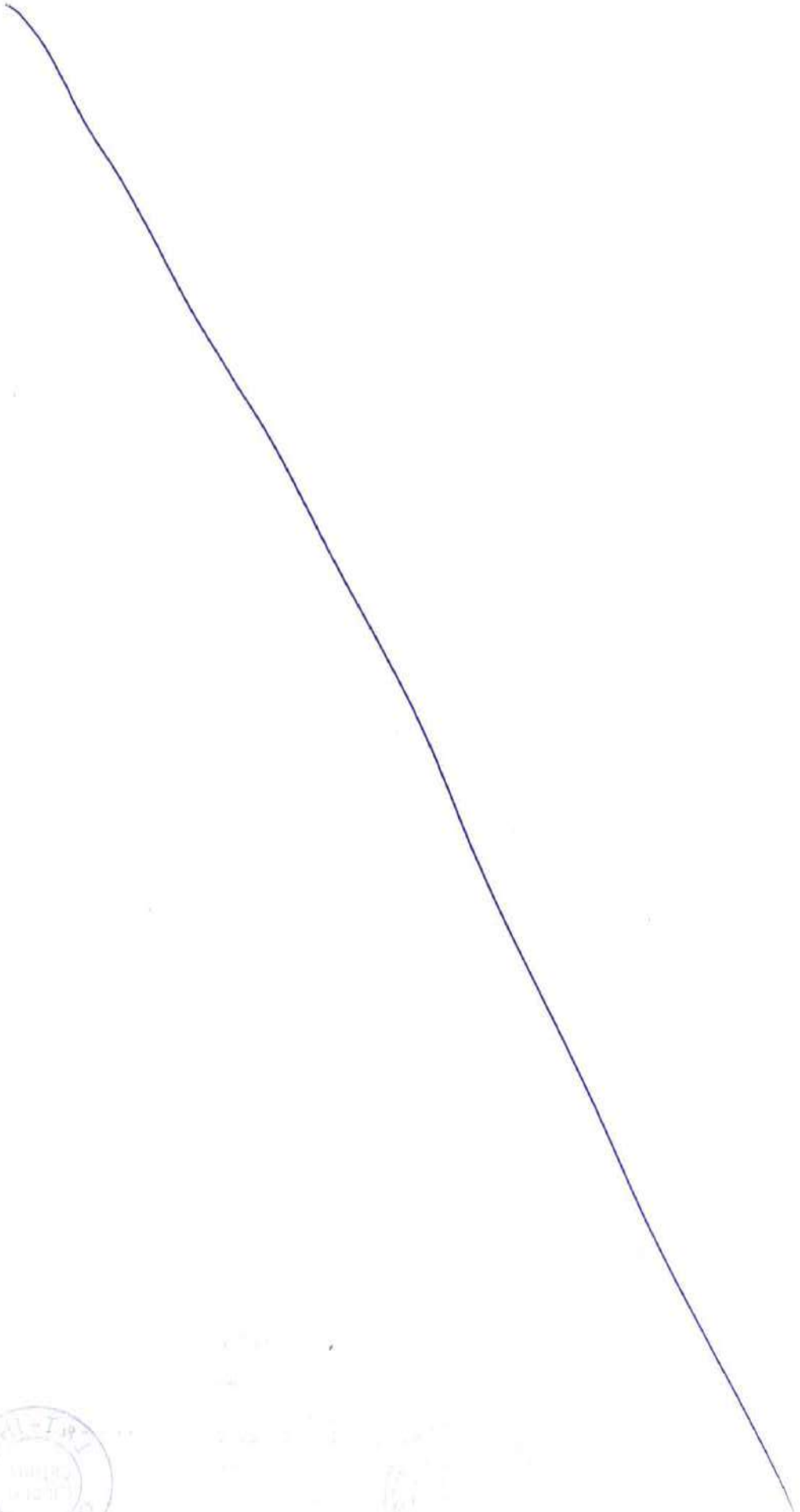
1) Efficient document control
2) Secure & efficient mailing process
3) Internal review
4) Audit review

b) The team will follow the reporting methodology on following areas

1) Any outstanding information from & to other contractors
2) Areas of immediate concern.
3) Immediate Information requirement for starting construction activity,
4) Change management These will be done by regular meetings on daily basis

Implement and maintain a strict monitored control of information transfer to the Interfacing Contractors, the Employer and the Employer's Representative utilizing the official channels of communication.

- Provide a comprehensive interface schedule of Interfacing Contractors, including specialist domestic interfaces (i.e. specialist testing and commissioning engineers) identifying all interfacing activities and timetables of events



- Arrange all internal and external interface meetings. The Employer's Representative may arrange regular meetings to monitor the status of interfaces, and may require special meetings as may be necessary to resolve specific issues. The _____ contractor Interface Management Team will attend such meetings. We may request assistance from the Employer's Representative to arrange meetings on particular subjects.

- Providing the Employer's Representative with all information and/or details interfaces, including copies of all correspondence and material.

- Providing the Employer's Representative with access to information for the purpose of conducting audits on the interface system and for confirming that interface co-ordination is proceeding consistently with the Project requirements.

2.2 Responsibilities

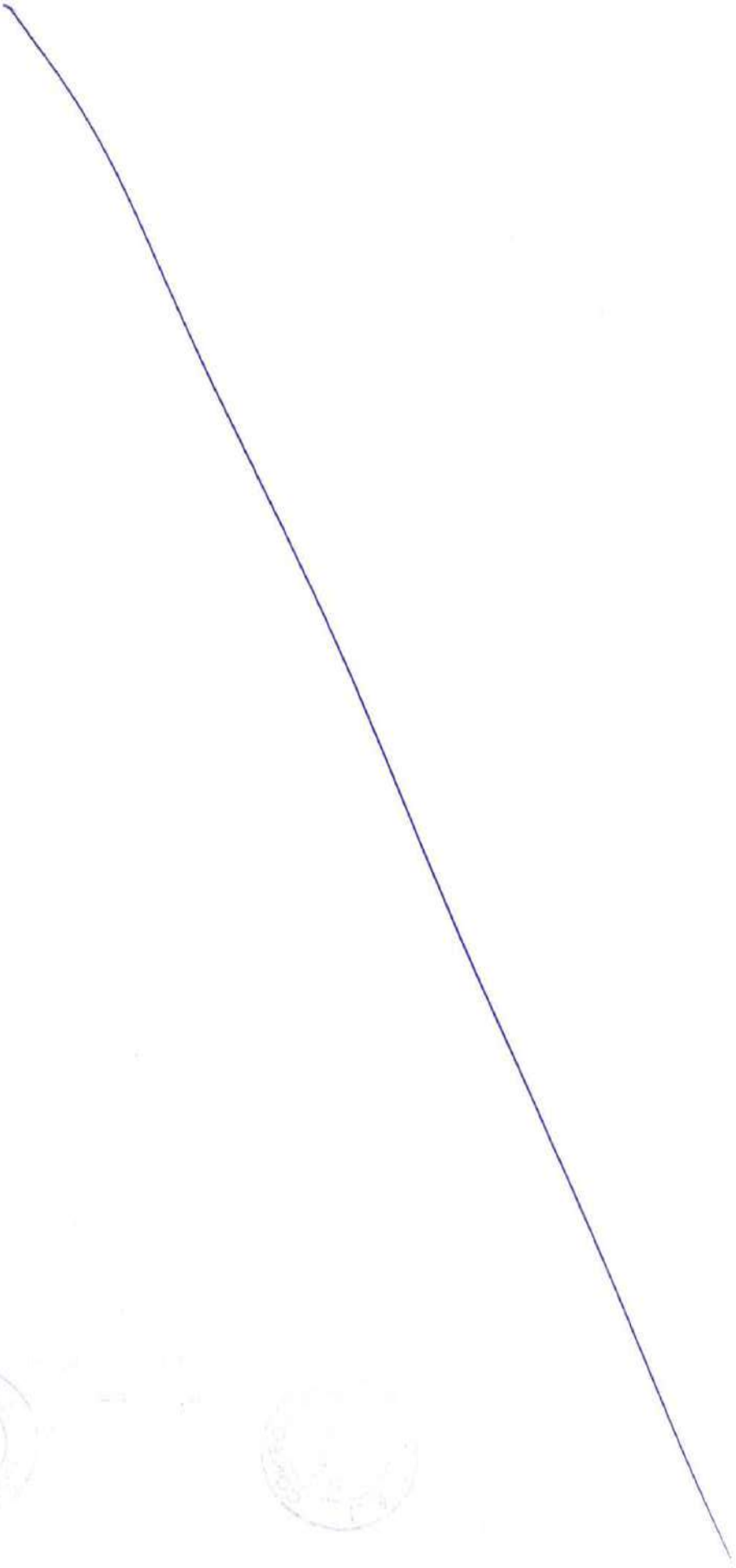
2.2.1. Chief Interface Coordinator (CIC)

The functions of CIC shall be as stipulated in contract. The works involved and job scope shall be

- Preparation and implementation of Interface Management Plan.
- Invite and Lead meeting with Interface contractors.
- Overall responsibility of identifying, communicating, facilitating and Resolving interface issues to the best of his knowledge and in line with provision of contracts within the time provided as per contract.
- Coordinating with Employer's Representative, taking up instruction from Employer's
- Representative and executing in compliance with the contract.
- Interface progress monitoring and reporting to ER on monthly basis.

2.2.3. Interface Engineer (Civil Architectural, Structural& finishes)

- Reports the interface issues identified both forecasted and also real time issues to CIC.
- Shall participate in Execution Interface meetings as an observer.



- Communicate the difficulties and time constraints on execution and forecasted delays in over the deliverables to CIC for reporting to the meetings.
- Produce simple report on work status in Depot to CIC for his understanding of interface implication on weekly basis
- Until the time of appointment of this post, Deputy Project Manager shall take up the responsibilities of Execution Interface Engineers.

2.2.4. Interface Engineer Services

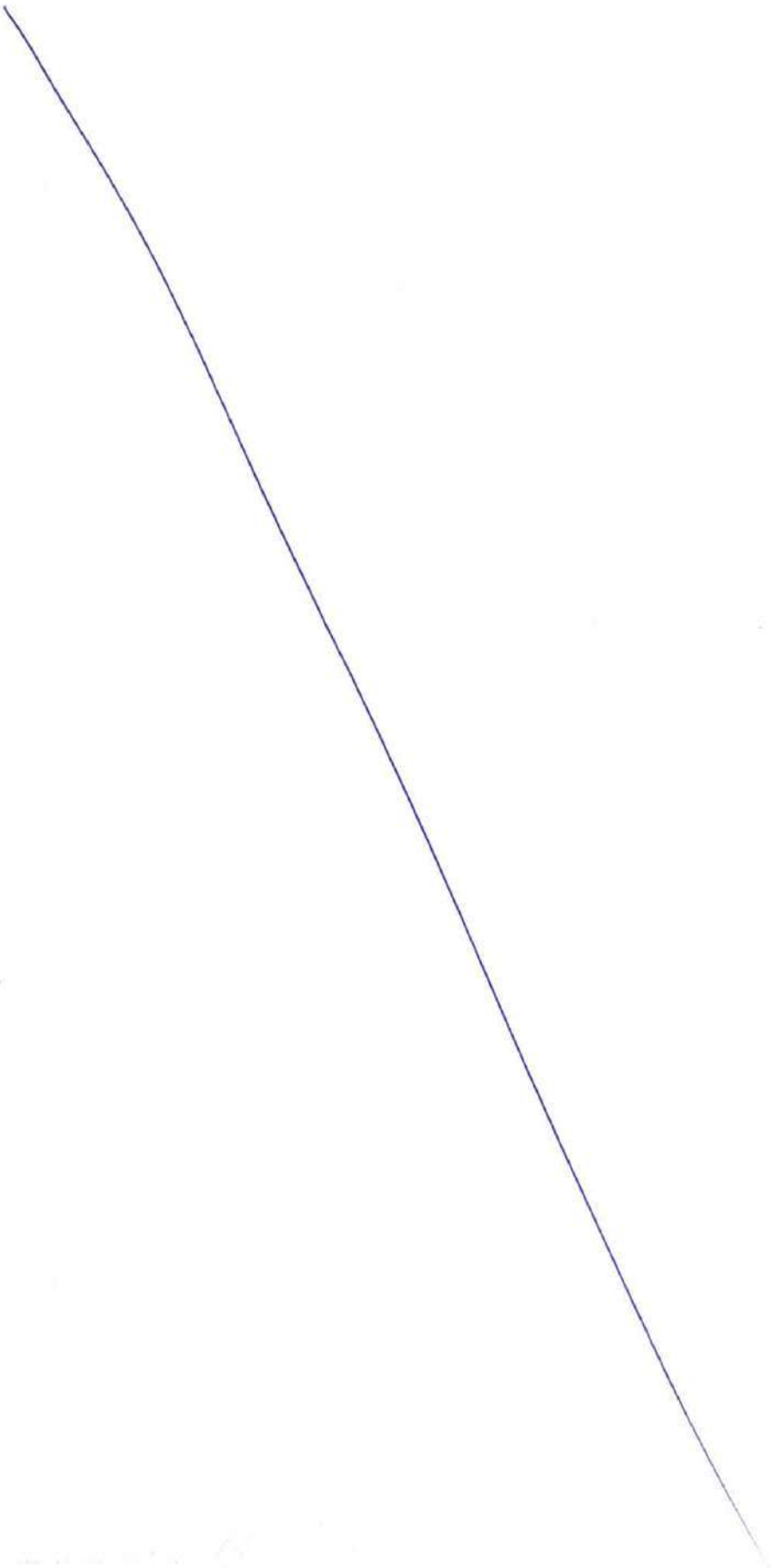
- Reports the interface issues identified both anticipated and also real issues to CIC.
- Shall participate in Execution Interface meetings as an observer.
- Communicate the difficulties and time constraints on execution and forecasted delays in handing over the deliverables to CIC for reporting to the meetings.
- Record and submit photographs of the execution stages like commencement, 25, 50, 75 and
- 100% of works related to interfacing contractors like Mechanical, Electrical, HVAC and
- Plumbing works.
- Produce simple report on work status in depot to CIC for his understanding of interface implication on weekly basis.
- Until the time of appointment of this post, MEP Design Engineer shall take up the responsibilities of Execution Interface Engineers.

2.2.5. Construction Interface Engineer Services (Civil, Structural & Architectural)

- Shall participate in Execution Interface meetings.
- Communicate the difficulties and time constraints on execution and forecasted delays in handing over the deliverables to CIC for reporting to the meetings.
- Record and submit photographs of the execution stages
- Produce simple report, on weekly basis, on work status in each station to CIC for his understanding of interface implication.

2.2.6. Construction Interface Engineer Services (MEP)

- Shall participate in Execution Interface meetings. Record and submit photographs of the execution stages like Mechanical, Electrical, HVAC and



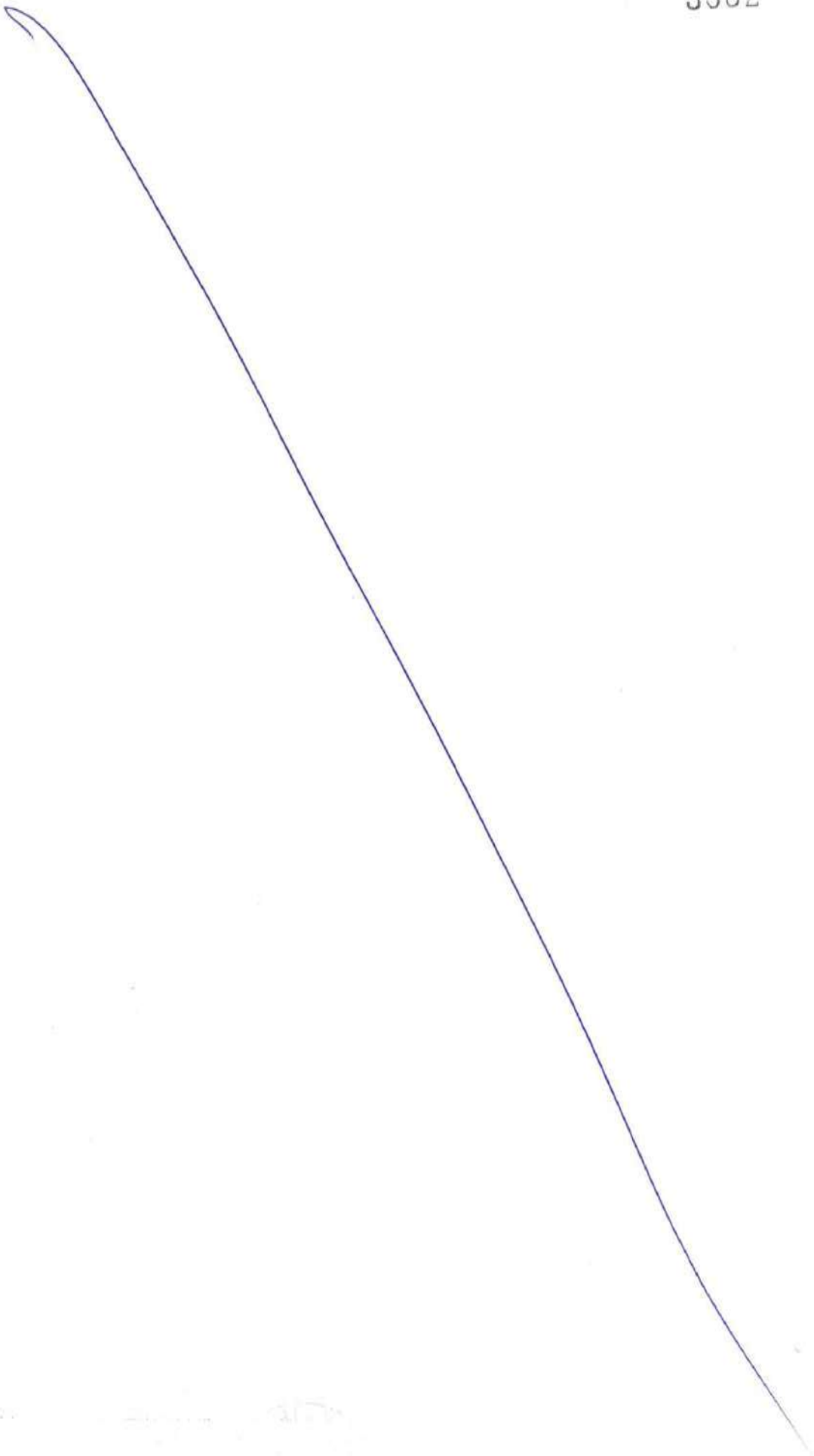
Plumbing works.Produce simple report, on weekly basis, on work status in each station to CIC for his understanding of interface implication

3. Communication and information exchange

- Contractor _____ will communicate, co-ordinate and exchange information directly with the Interfacing Contractors and we keep the Employer's Representative advice at all times. Information necessary to fulfill the obligations shall be directly requested and obtained from the Interfacing Parties, and receipt acknowledged. Conversely, we will provide directly to the Interfacing Contractors information within the Contractor's scope that is required by them.
- All requests for information, acknowledgement of receipt of information, and any official communication between the Contractor and the Interfacing Contractors shall be made in writing, with a copy to the Employer's Representative for his information. The Employer's Representative shall be invited to attend all interface meetings between the Contractor and the Interfacing Contractors. Irrespective of whether these meetings were attended by the ER or not, the contractor's monthly progress report to ER shall invariably include the details of all interface meetings held and decisions arrived.

The _____ contractor programme shall allow time for the availability of necessary interface information from the CIC and in this regard we shall, where required, proceed on a late start basis to allow adequate time for others to provide required information and thereby achieve design process compatibility.

The Contractor shall allow for the fact that many of the design and construction activities for the different contracts will be proceeding concurrently. In the event that certain interface information is not forthcoming at the time targeted, the Contractor shall be responsible to resolve the matter with the relevant Interfacing Contractor without recourse to the Employer's Representative, and where necessary develop alternative interim arrangements such that the interface information may be accommodated at a later date. Definitive dates for transfer of information and particular interface actions shall be Confirmed between the Contractor and the Interfacing Contractors using three month rolling interface management programme



Interface Communication Module

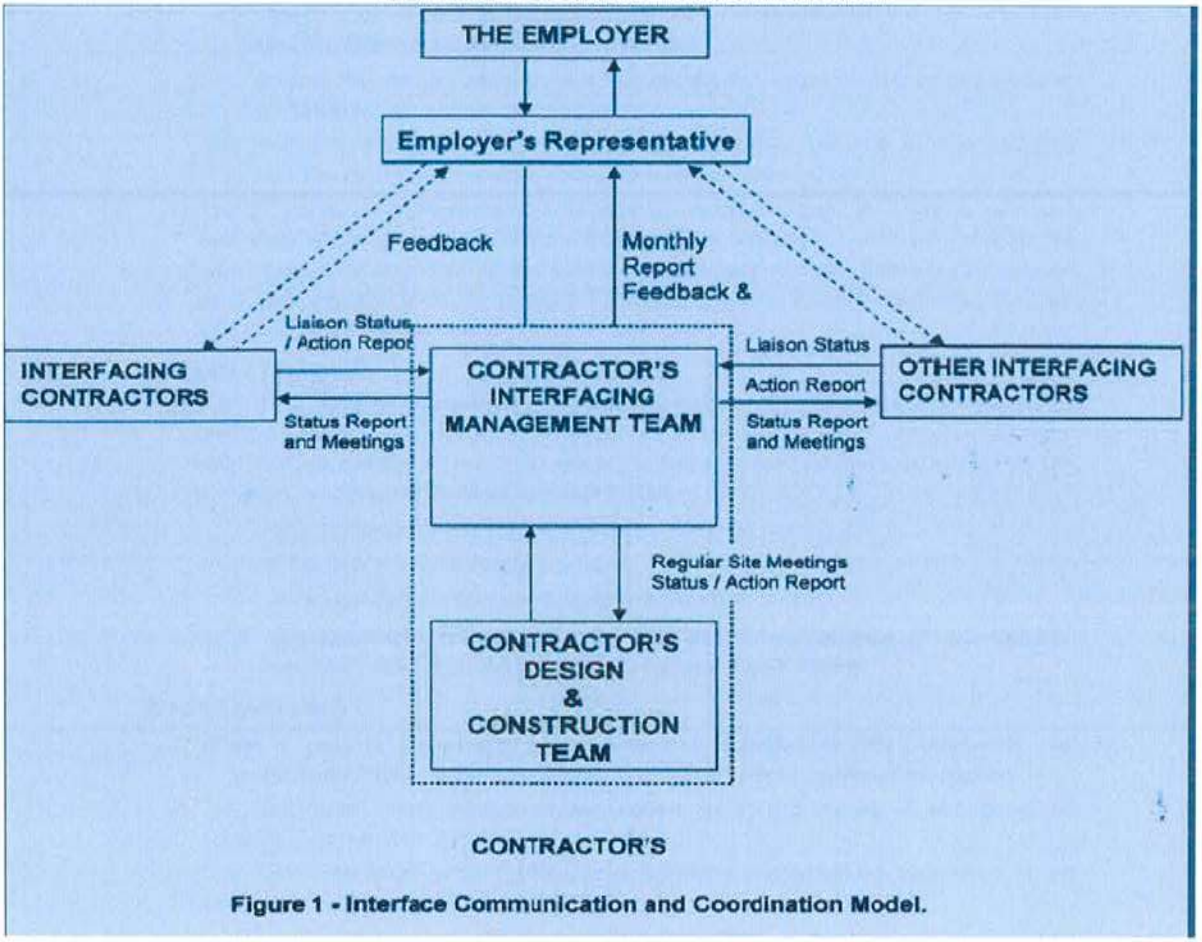
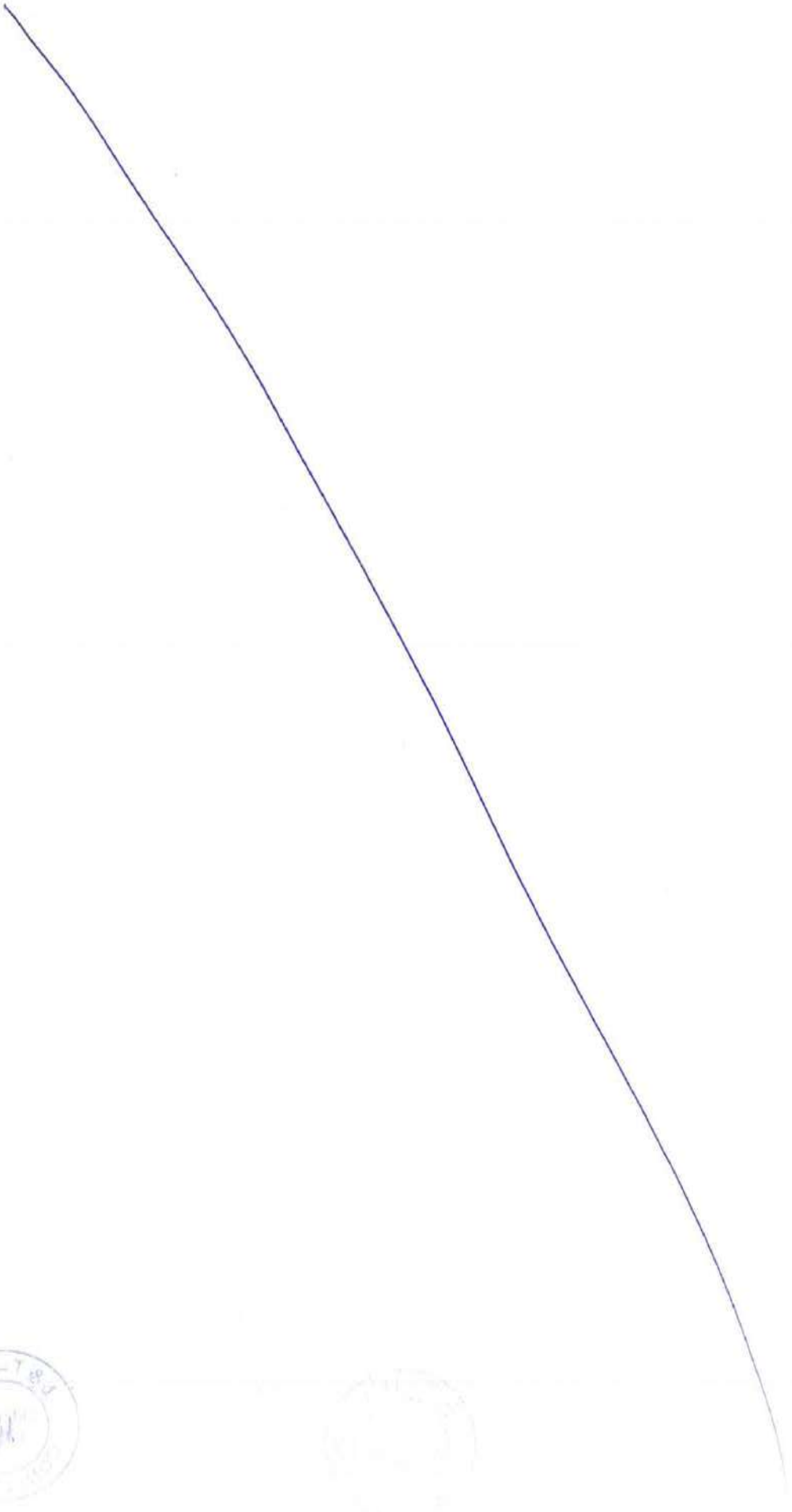


Figure 1 - Interface Communication and Coordination Model.

3.1 Interfacing functions

The _____ Contractor is responsible for, but not limited to, the following;

- The management of Contract to Contract Interfaces as required;
- preparing the Interface Management Plan and subsequent procedures;
- Preparing the Interface Management Programme in accordance with this procedure and submitting these to the Interfacing Contractors for concurrence.
- Preparing the Interface Management Programme and submitting these to the Employers
- preparing their Interface Coordination Sheets and Interface Specifications and issuing same ICS updated continuously and attaching it to their Monthly Progress Report submitted to the Employer's Representative in accordance with the requirements of the Contract .



3.2 Design stage

The design interface is an iterative process, thus throughout the design process, the Contractor shall be responsible for coordinating his own design with Interfacing Contractors to develop interface designs in conjunction and co-operation with the designers of Interfacing Contractors. These interface designs will be monitored and have to be given Notice of no objection by the Employer's Representative, but on the other hand work directly with the Interfacing Contractors to develop designs which are mutually acceptable to all parties.

We will, immediately upon Contract Award, gather all necessary information and develop his design to a level where meaningful interaction can take place as soon as the Interfacing Contractors are available.

3.3 Interface design change process

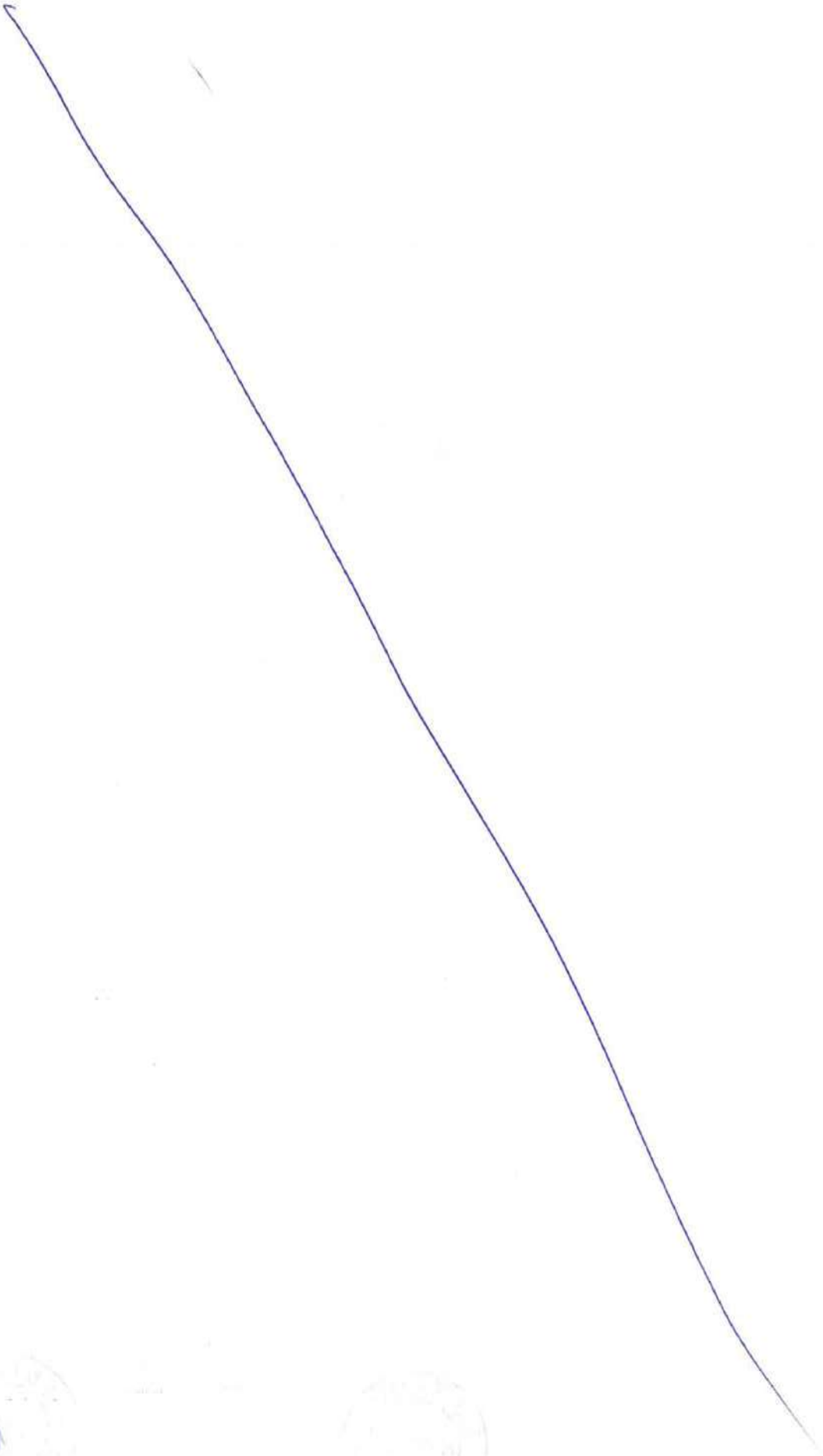
We will establish an interface design change process to ensure that:

- All proposed changes for a specific interface are reported, recorded and resolved;
- Proposed changes are fully evaluated; and
- Internal/External communications and distribution paths are properly

3.4 Construction phase

During construction, when a construction item is ready for field inspection, advise the Interfacing Contractor in advance to verify compatibility with the Interfacing Contractor's needs. We shall:

- Advise the Interfacing Contractors in writing when the as-constructed interface- related work can be inspected, and provide the necessary Site access and occupation
- request in writing and obtain from the Interfacing Contractors, interface information required for that stage of the Contract;
- agree in writing with the Interfacing Contractors on the adoption of any applicable comments on the constructed work;
- agree that any testing and commissioning for works can be carried out in accordance with the Interface Management Plan;



- conduct on-Site inspections of the work elements, and give comments in writing to the Interfacing Contractors;
- Agree in writing with the Interfacing Contractors that the as-constructed work meets the interface requirements.
- Where the execution of work by Interfacing Contractors depends upon the site management or upon information to be given by the Contractor, the Contractor shall provide the Interfacing Contractors with the required services or the correct and accurate information required to enable the Interfacing Contractors to meet their programme for the construction or installation of their works.

3.5 Interface commissioning

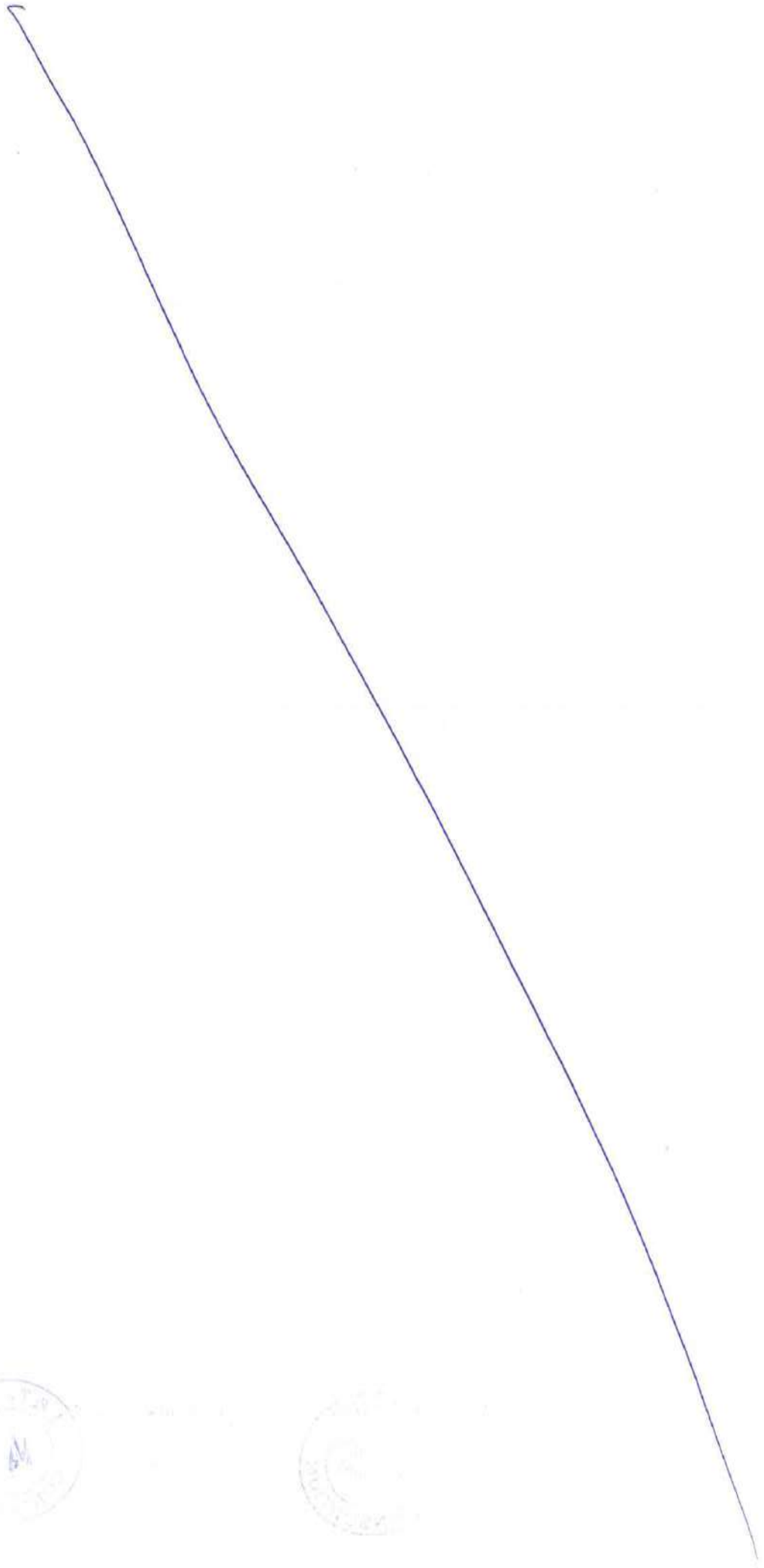
WE will co-ordinate all of his testing and commissioning activities with the Interfacing Contractors. Interface commissioning will demonstrate that the delivered interface, part A of the interface, is ready and meets the interface requirements of the interface part B, and vice versa.

Successful completion of all interface commissioning shall prove its readiness for commissioning of the overall contract scope and completion of the overall Metro-rail Project, prior to handover to the Employer for their commercial operation.

3.5.1 Interface Meeting Schedule

To have a regular flow of information between various interface stake holders, We will be following this schedule. The schedule will be reviewed every month and if required frequency of meeting with Interfacing contractor shall be increased

S.No.	Interface Scope	External Entities	Schedule
1			
2			
3			
4			



3.6 Testing and Commissioning

For each interface it shall be carefully considered how fulfillment of the requirements can be verified through testing. Depending on the respective interface such tests will be usually performed during the On Site Tests, in one of the phases Installation Completion Inspection, Test on Completion or Integration Test. For some of the interfaces the installation on site itself will be the ultimate test

Interface tests to be performed shall be taken into account when the On Site Tests are planned

3.7 Interface and Hazard Analysis

The assessment of risks in a system while operation depends to a greater or lesser extent upon the judgment of, and assumptions made by, the analyst carrying out the process. To think otherwise is to misunderstand the risk and hazard analysis. Given this fact, it is important that necessary information and data be provided to support the judgments that the analyst needs to make and, in turn, maximize the accuracy and validity of the analysis.

The first step in any risk assessment—qualitative or quantitative— is to identify the hazards to be assessed. At a more detailed level, the causes (faults or errors) leading to a hazard can be identified.

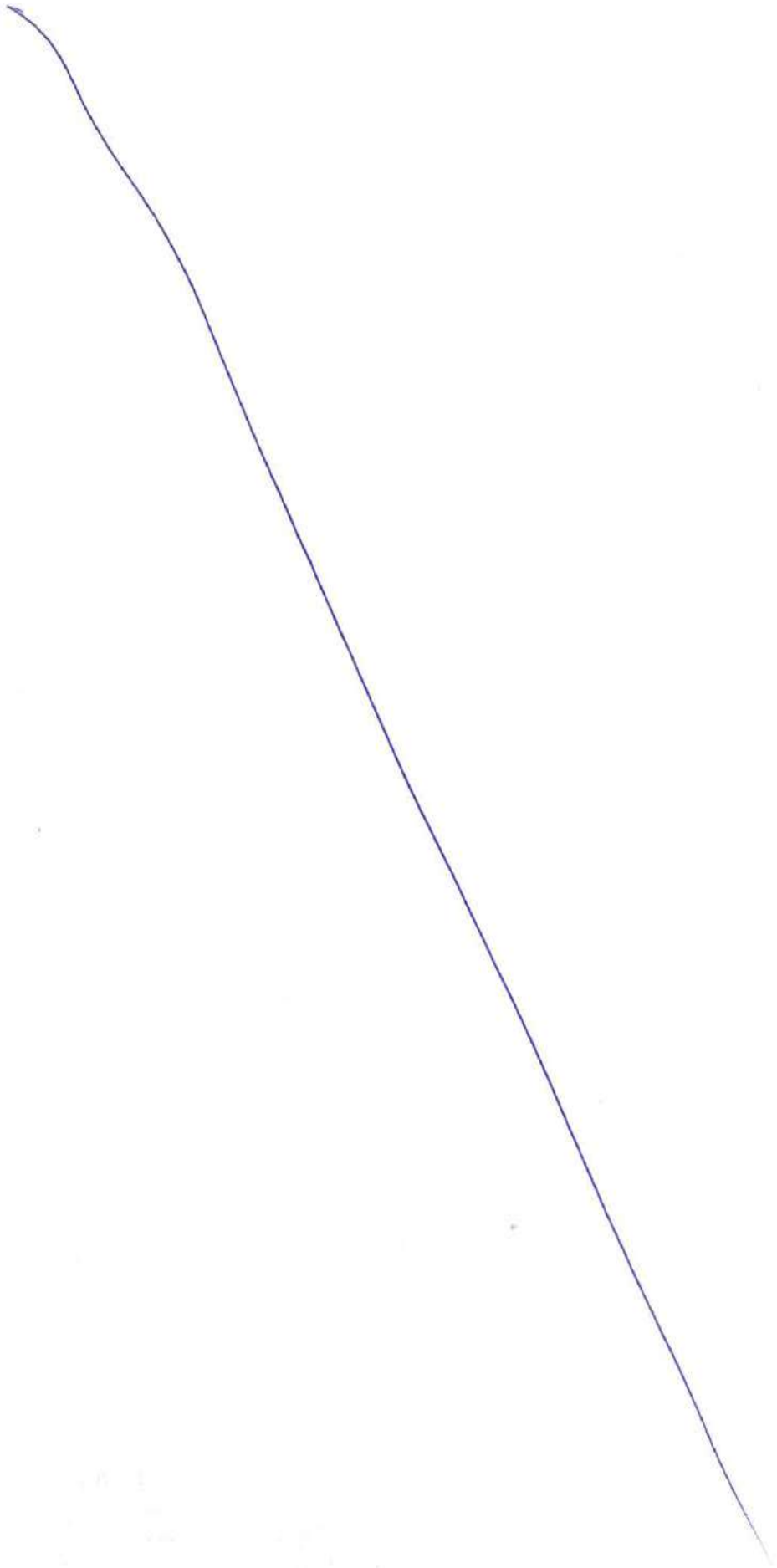
Parts of hazard analysis are:

- Preliminary hazard analysis (PHA)
- System hazard analysis (SHA)
- Interface hazard analysis (IHA)
- Operating and support hazard analysis (O&SHA).

3.8 Change Requests

During the project life cycle it may be necessary to change the interface requirements to facilitate the installation, correct errors and minimize risks. Changes to an interface, after this has been officially accepted by the involved interface partners must be performed adhering to a formal procedure which ensures that

- The implications of the proposed change are clearly evaluated with respect to de- sign, Costs and schedule;



- Changes are agreed to by all interface partners and the GC;
- Necessary changes are tracked until completion.

3.9 Resolution of coordinate difficulties

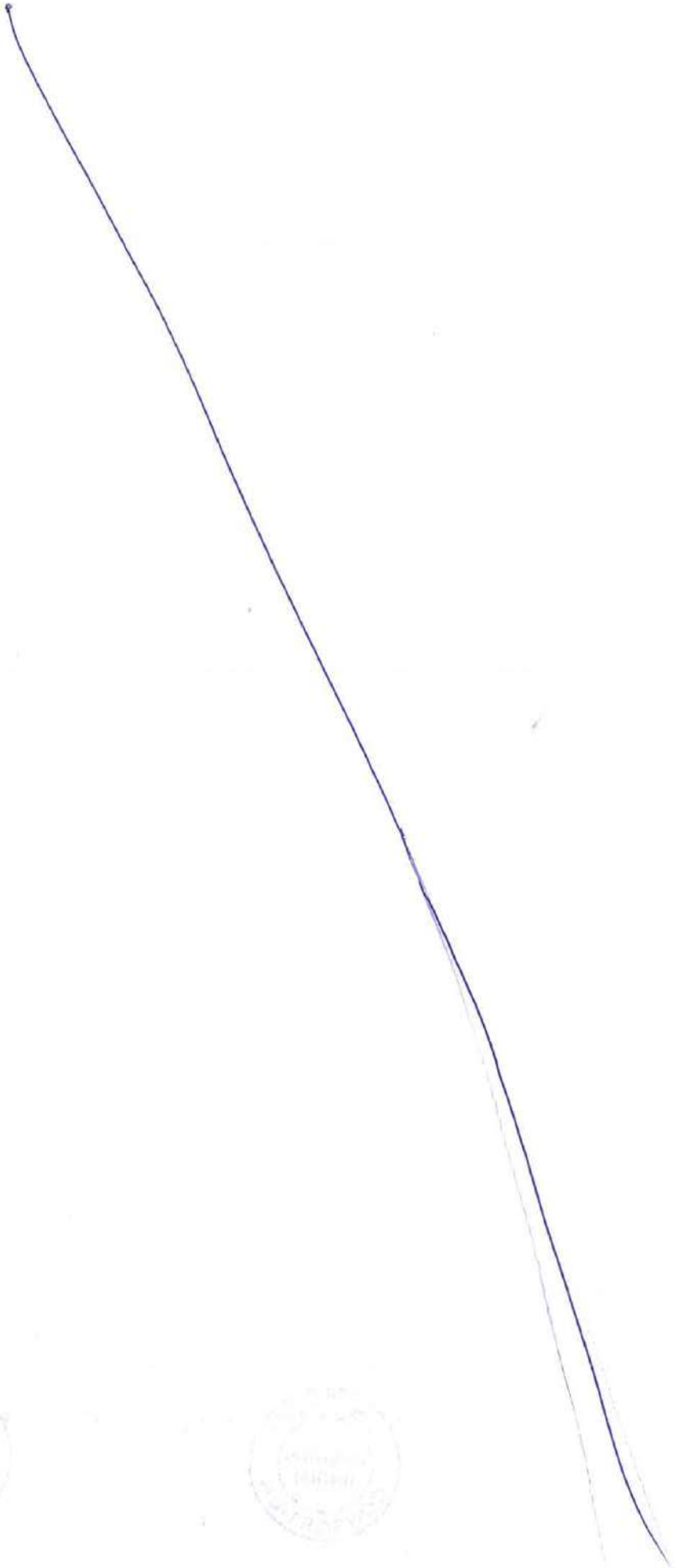
When we identifies interface co-ordination difficulties, we shall review the pertinent points of each Interfacing Contractor to determine possible compatible solutions in terms of sequence, timing and technical details. We shall then meet with the relevant Interfacing Contractor(s) to determine solutions, which are mutually acceptable to each Interfacing Contractor and advice the Employer's Representative.

Where an acceptable solution has not been identified, the Contractor shall advise the Employer's Representative in writing of the problems encountered. If, in the opinion of the Employer's Representative, an interface is not proceeding satisfactorily, then the Employer's Representative will review the matter, and establish a co-ordinate plan directing the Contractor and the Interfacing Contractor(s) on the required action. In the event that no agreement can be made between the Contractor and the Interfacing Contractor(s), the Employer's Representative shall determine the requirements to the best of his knowledge, and his determination shall be final and binding on the Contractor and the Interfacing Contractor(s).

3.10 Interface Performance

The Contractor's performance in relation to his compliance with the interface requirements under the Contract shall be assessed by the Employer's Representative3 months after the Commencement Date and thereafter at three monthly intervals.The assessment will be in the form of an audit of the _____ interface management system. This audit will assess the compliance with the responsibilities delineated and elsewhere as related to interface management and the preparation of the Interface Management Plan and Programme and other documentation and procedures associated with Interface Management and Coordination.

The Contractor will be notified of non-conformances from the audit, which will require rectification. Where, in the opinion of the Employer's Representative, the Contractor has failed to rectify a non-conformance within a reasonable period from the date of notification, this may lead to non-payment



of any lump sums, until such time as the non-conformance has been rectified to the satisfaction of the Employer's Representative. The Contract allows for continuous audits of the Contractor's compliance with his Interface Management Plan and the requirements of Volume 3 Employer's Requirements and any extreme or continuing failures shall result in a negative audit report, which may lead to non-payment of the relevant payment item in the Preliminaries section of the Pricing Document. The decision of the Employer's Representative in this regard shall be final

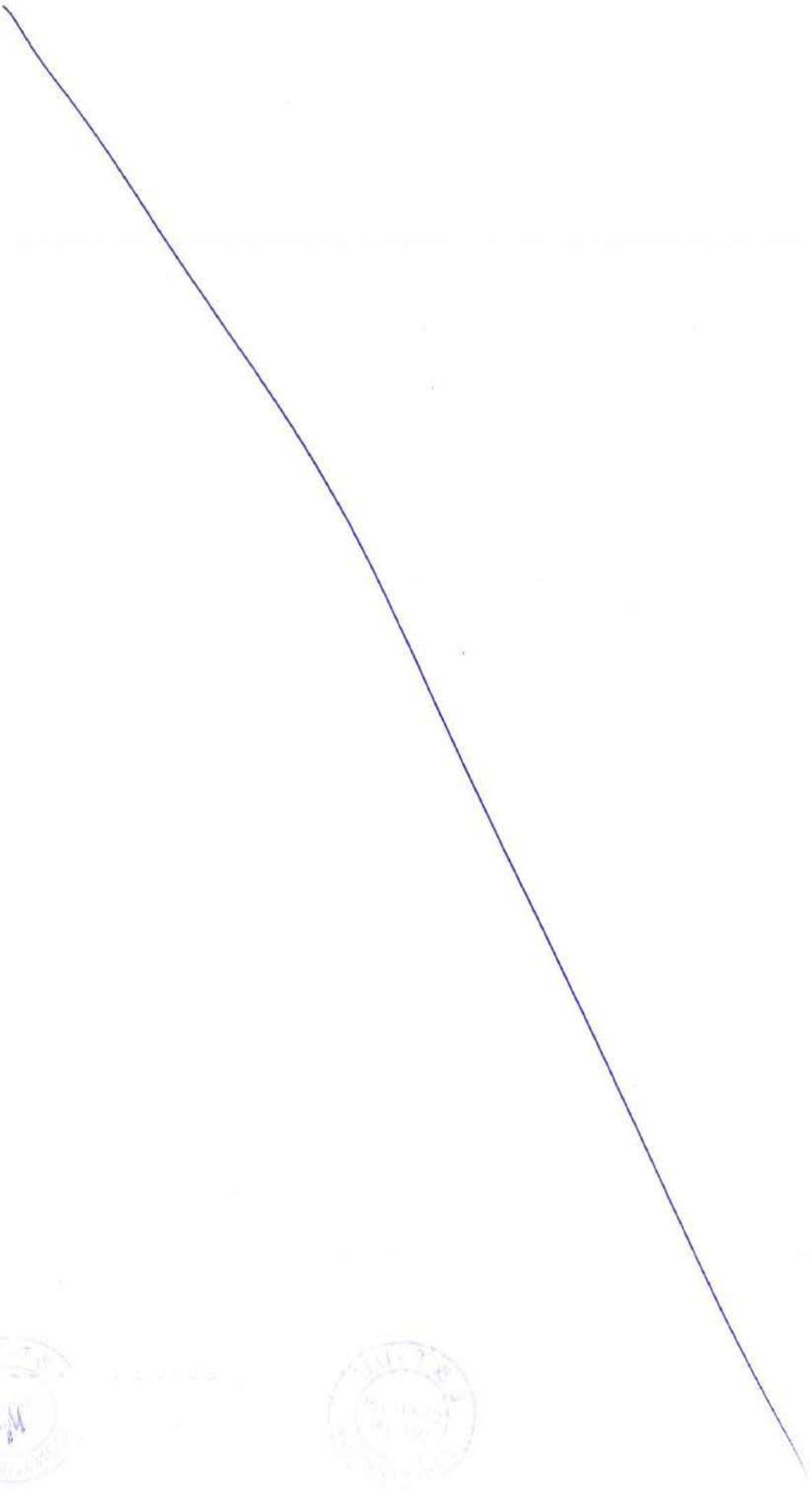
a. Performance measurement and monitoring

L&T-IHI Consortium undertakes active and reactive monitoring and measurement exercises to determine the effectiveness & robustness of the Management System. In addition the Company's routine monitoring activities additional requirements have been introduced to comply with the Employer's Requirements. All interface performance monitoring exercises are subsequently reviewed and analyzed within the project team as a minimum. Certain exercises are stipulated as Organizational Key Performance Indicators therefore results of such are subject to review at Head office levels. Where best practice techniques are recognized these are subsequently promulgated across the organization within internal communication channels of the organization

The Project Manager measures the performance of its processes by:

- Evaluating the Work relative to interface coordination and implied requirements;
- Assessing the capability of its processes;
- Comparing the achievement of interface coordination against project expectations;
- Examining comments received from the Customer and other interface agencies.

The process of measurement, analysis and improvement is performed in full for all processes and is addressed via the applicable process procedures. The items covered include, for example, conformity of products, conformity to the Quality Management System, Customer satisfaction, characteristics and trends of processes and products highlighting opportunities for preventive measures and improvement. The range of routine performance monitoring exercises is described herein in detail together with the responsibility for implementation and reporting timescales, these include:



b. Customer satisfaction measurements

The company monitors customer satisfaction as proactive activity to assess whether the company has met the expectations of the customer. This activity is done by respective CIC and Project Manager based on questionnaire () issued by QMC. The Project
Manager/CIC gets the feedback from customer using such questionnaire or other proactive feedback.

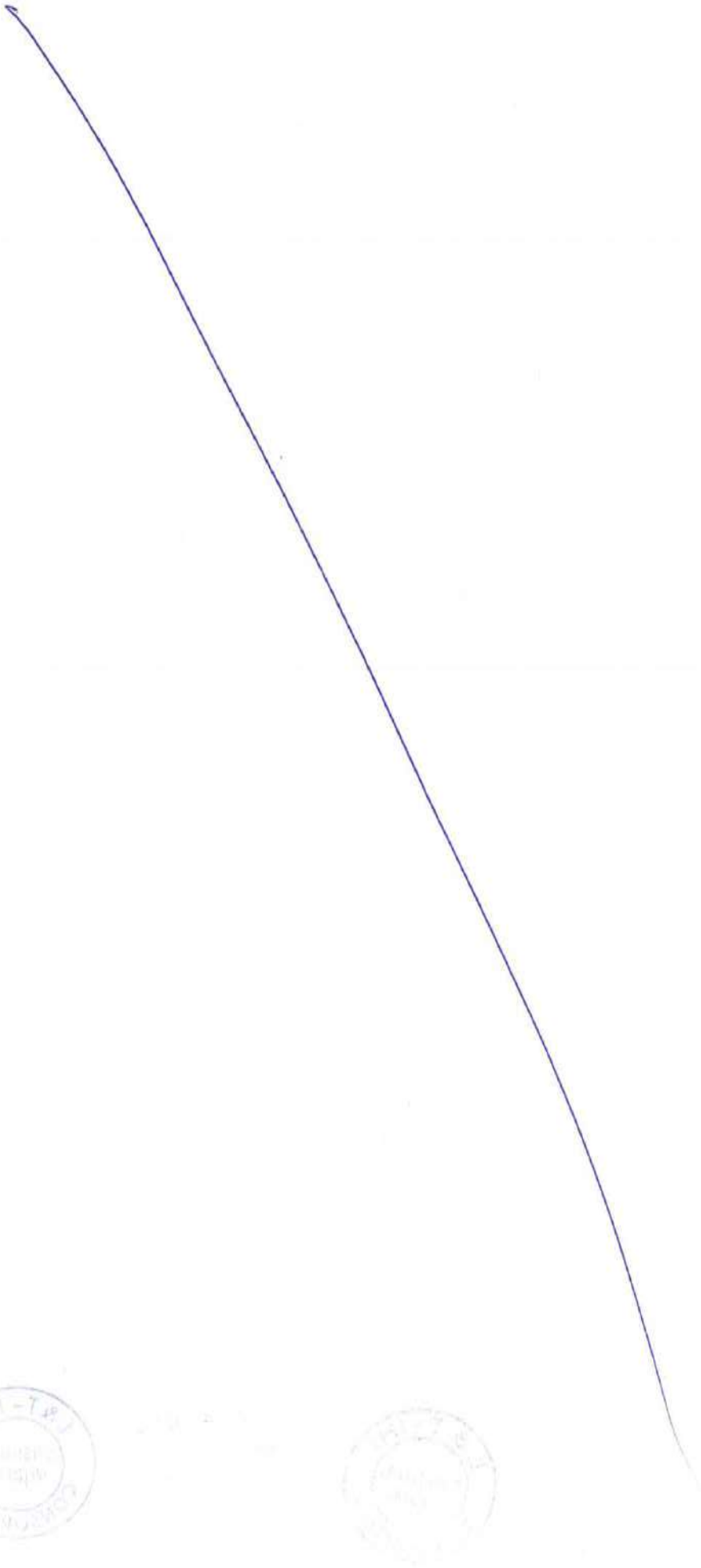
Such feedback is collected from all the customers twice in a year. The findings of this feedback are reported in management review meeting. Corrective actions are taken when it is felt necessary.

c. Internal Audits

The corporate and site management representatives separately plan the internal audit program. The internal audit exercises are initiated by the corporate management representative at least once in six months at selected sites and Head office, such that every site is audited at least twice in its life time. The corporate QMC prepares the corporate audit plan on the basis of the status and importance of the site/activity to be audited.

The internal audit exercises are initiated by the site management representative at least once in three months. The site QMC prepares the site audit plan on the basis of the status and importance of the activity to be audited. Based on these plans, the CIC prepares a schedule indicating the names of internal auditors, the site/department to be audited and the dates.

a. Trained employees of the company conduct the Internal Audit.
b. It is ensured that the audit is carried out by auditors who shall ensure the objectivity and impartiality of the audit process. Also auditors shall not audit their own work.
c. The auditors make a report of the audit and brief the head of the section & site-in-charge about the result of the audit.
d. The Head of sections /Project manager takes the appropriate corrective action on deficiencies found during the audit within the defined time frame. The effectiveness of the corrective action is verified by re-auditing.
e. The result of internal audit forms a part of the agenda for the Management review.
f. CIC shall keep the records related to audit results, actions taken for follow-up activities and its analysis.



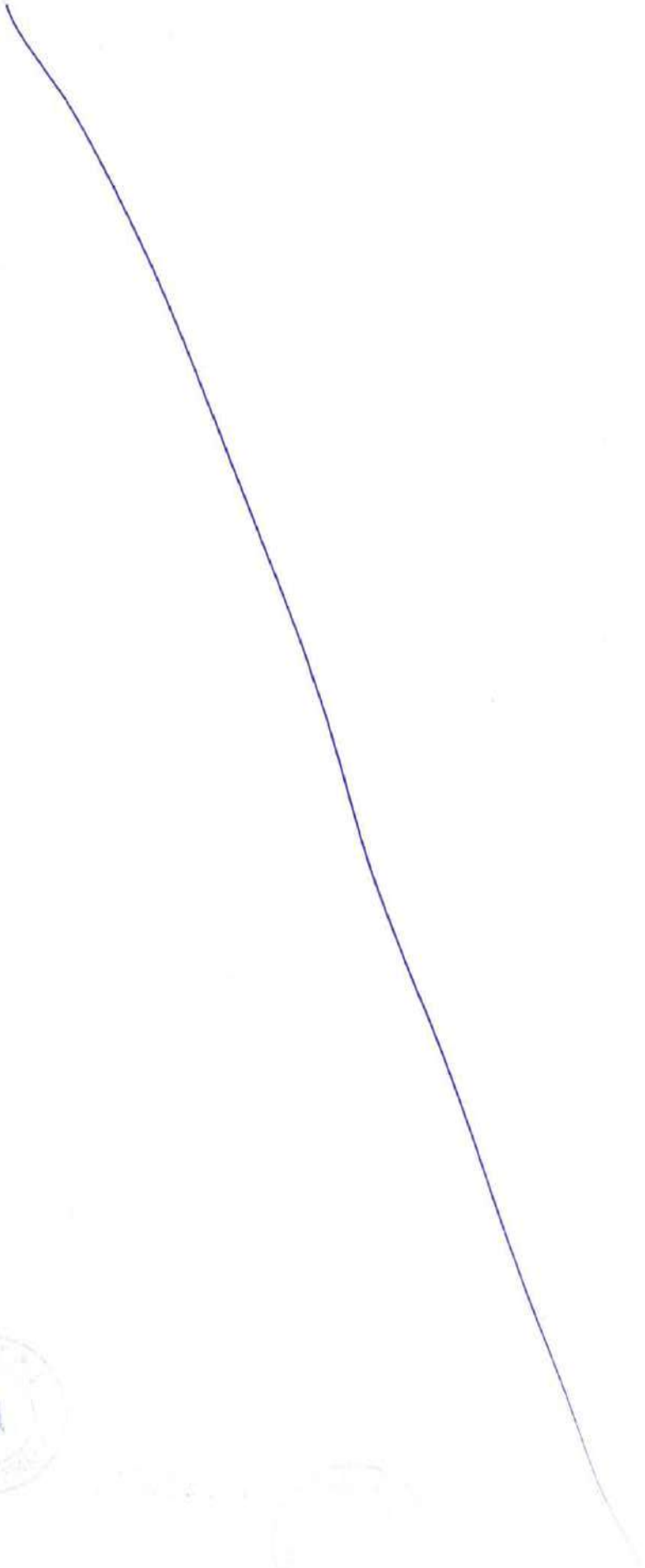
g. The details of the process of Internal audit are documented in corporate procedure for Internal audit ()

INTERNAL AUDITS					
Sl.No.	L&T-IHI Consortium				Management Review
	Date of 1st Audit	Date of 2nd Audit	Date of 3rd Audit	Date of 4th Audit	
1					Quarterly

The management responsible for the area being audited shall ensure that any necessary corrections and corrective actions are taken without undue delay to eliminate detected nonconformities and their causes.

d. Other forms of performance monitoring

- External Audits carried out by a 3rd party independent auditor
- Analysis of internal non-conformances reports
- Site Instructions issued by the Employer's Representative for safety improvement;
- Employer's Representative inspection results, customer complaints and other feedback
- Site inspections conducted by the Engineering & Project Management Teams.
- Work stoppages invoked internally and by the Employer's Representative due to unsafe acts or conditions;
- Monitoring of document submittals status
- Analysis of rejections for not being in compliance with stated safety measures or Inspection and test Plans
- Analysis of incidents, occurrences of fatalities, major & minor injuries, dangerous occurrences, near-misses, damage reports for equipment and public property, accident Incidence and frequency rates
- Corrective and preventative measures identified and achieved
- Nonconformity, corrective action and preventive action



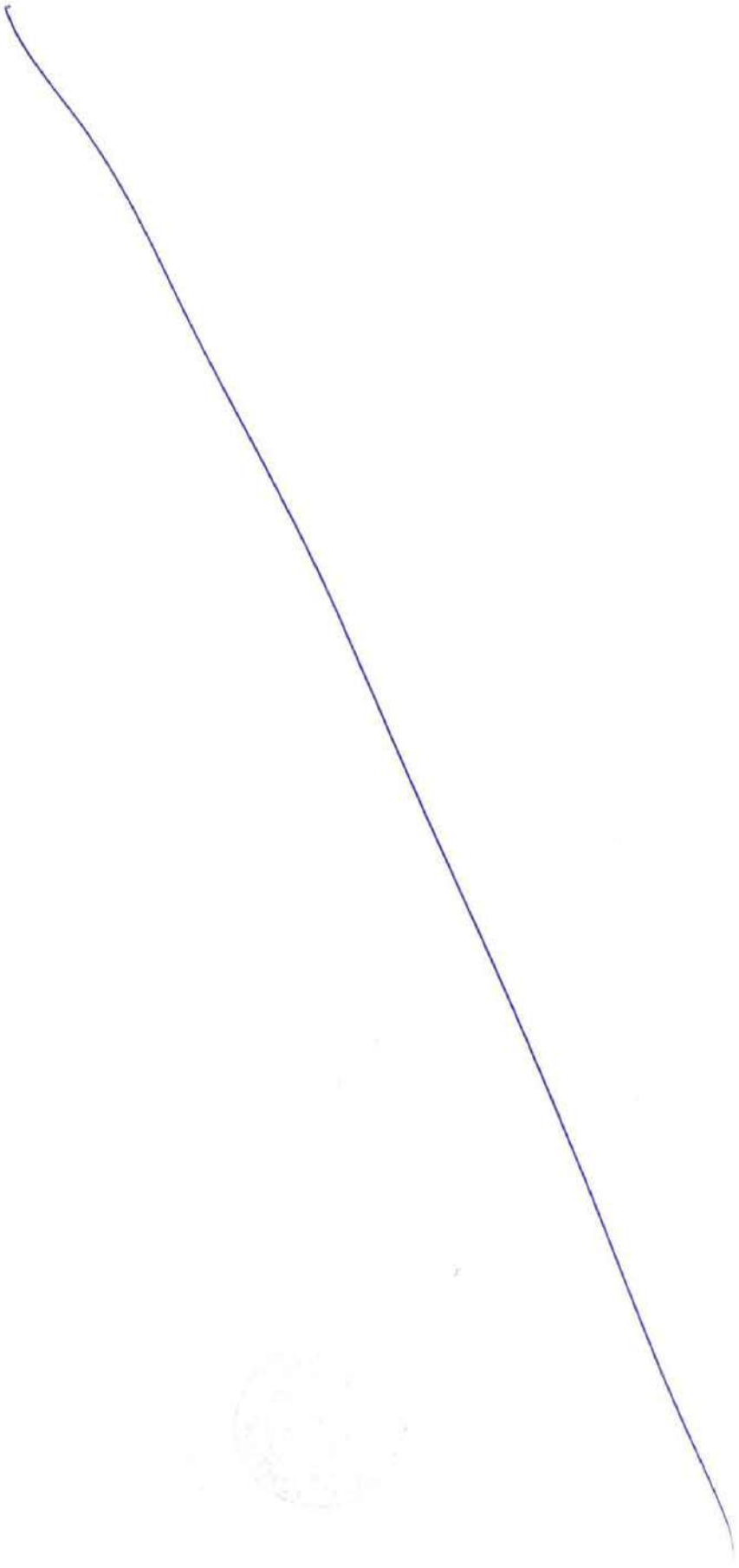
e. Corrective and preventive action

The procedure for corrective and preventive action () has been established as described below to take corrective action to eliminate the cause of actual nonconformities in order to prevent recurrence and to take preventive action to prevent similar nonconformities by taking action on potential causes and to eliminate potential nonconformities. This procedure includes controls for review and action on

- customer complaints and other nonconformities which have severe ramifications to the business and stakeholders
- relevant processes, work operations, audit observations
- negative trends based on data analysis

Based on this opportunities for improvements are identified and taken up as improvement projects after ratification by the management team. The improvement project uses the methodology described below:

- Investigation of the causes of actual/potential non-conformity and identification root cause/s
- Determination of the corrective action needed to eliminate the causes of actual non conformities appropriate to the magnitude of the cause and its effect and the need for the same.
- Determining the potential nonconformities and their causes and evaluating the actions required (appropriate to the needs and magnitude of problem) to prevent occurrence of nonconformities.
- Application of controls to ensure that improvement action (corrective and preventive action) is taken and that it is effective by identifying personnel responsible and fixing target date for completion.
- Records of such corrective and preventive actions shall be maintained as specified in the process. Status on improvement actions (corrective and preventive actions) for a given period is reported to Management Representative which are summarized and reported in the Management Review Meeting.

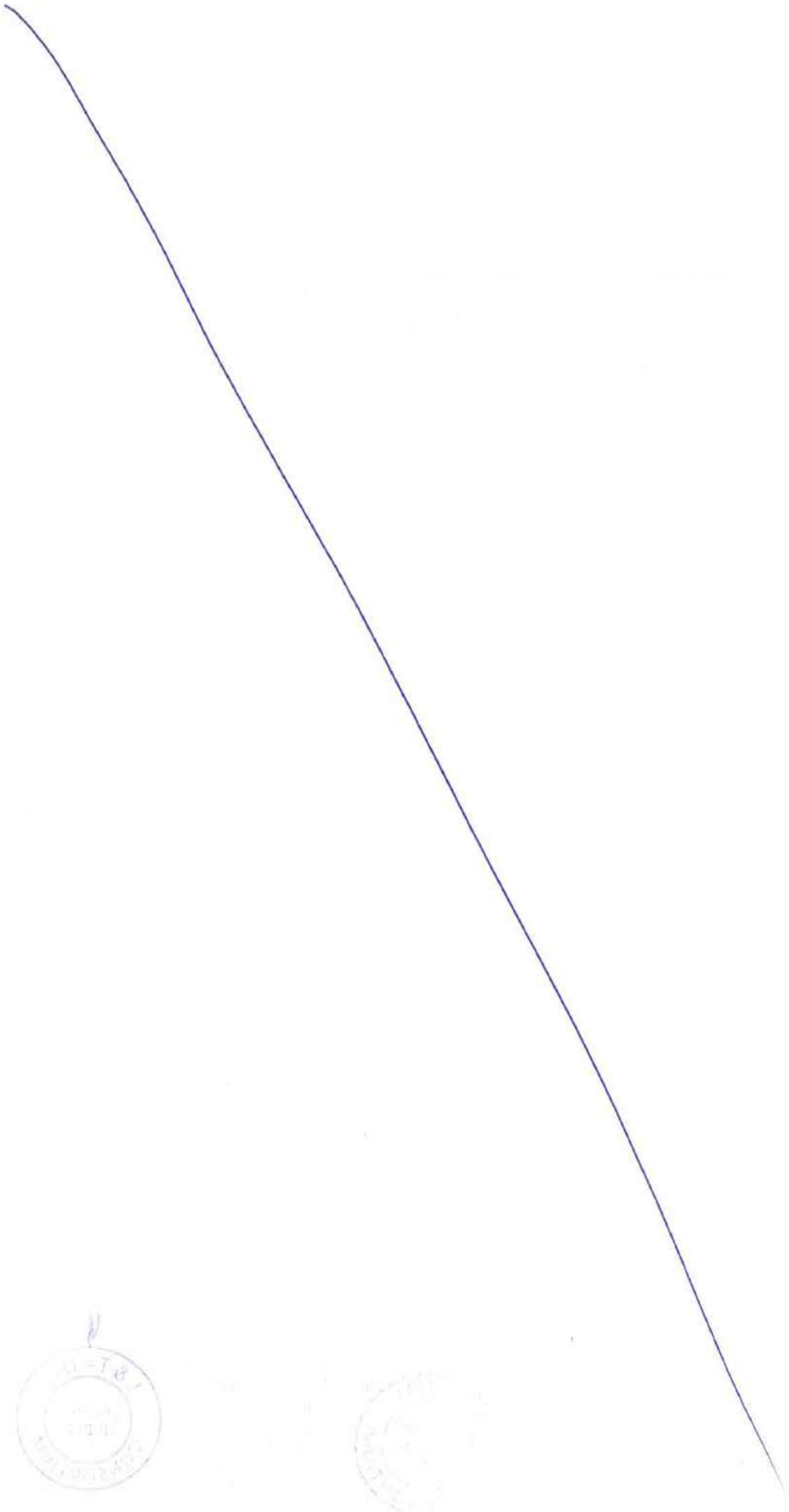


f. Management Review Meeting

Review of Integrated Management Systems is carried out at quarterly to planned intervals to ascertain the effectiveness of the System for the purpose of improvement under the leadership of the Project Manager.
The input to the management review meeting covers

- Follow – up actions from earlier Management Reviews if any
- Result of Internal / External Audits
- Customer Feedback and Complaints
- Performance against Quality, Environmental & OHS Objectives
- Measurements on Process Performance and Conformity
- Compliance Status of Statutory / Legal and other Requirements including changes therein
- Relevant communications from external parties about Environmental & OHS issues including complaints
- EMS Performance
- OHS performance
- Results of Participation and Communication
- Accident, Incident Report and their Analysis
- Status of Corrective and Preventive Actions
- Changes that could affect the IMS Management System
- Recommendations for Improvements

CIC shall conduct management review meeting once in a quarter. He shall fix date in advance in consultation with Project Manager. He shall inform all the section in-charges well in advance regarding the date, time and venue of the meeting. The agenda for the meeting shall be prepared by the CIC covering all the inputs as mentioned above and shall be distributed to all the section in charges.
CIC shall maintain copy of minutes of meeting and actions taken. CIC shall send to corporate QMC, copy of the minutes of meeting as well as report of monitoring of corrective and preventive action taken to corporate QMC. Any changes to be made in the methodology of process, objectives and targets shall be discussed in such meeting.
Meeting minutes are used to communicate the effectiveness of the QMS / EMS / OHSAS, and to document continual improvement progress.
There shall be weekly meeting at site level to review the interface coordination at site and to take corrective action if necessary.

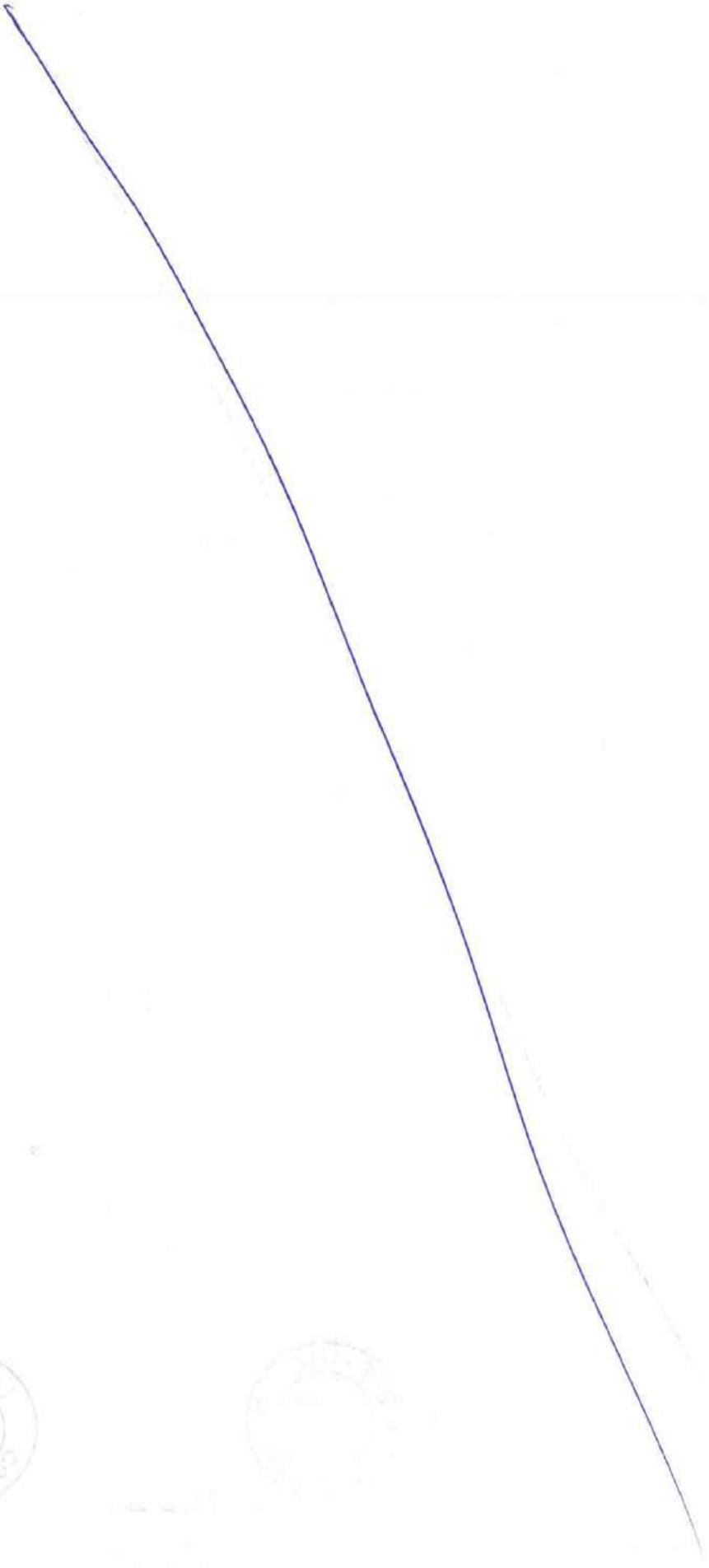


DMD/Executive Director/CMS shall review the project once in three months records of which shall be maintained by the project managers.

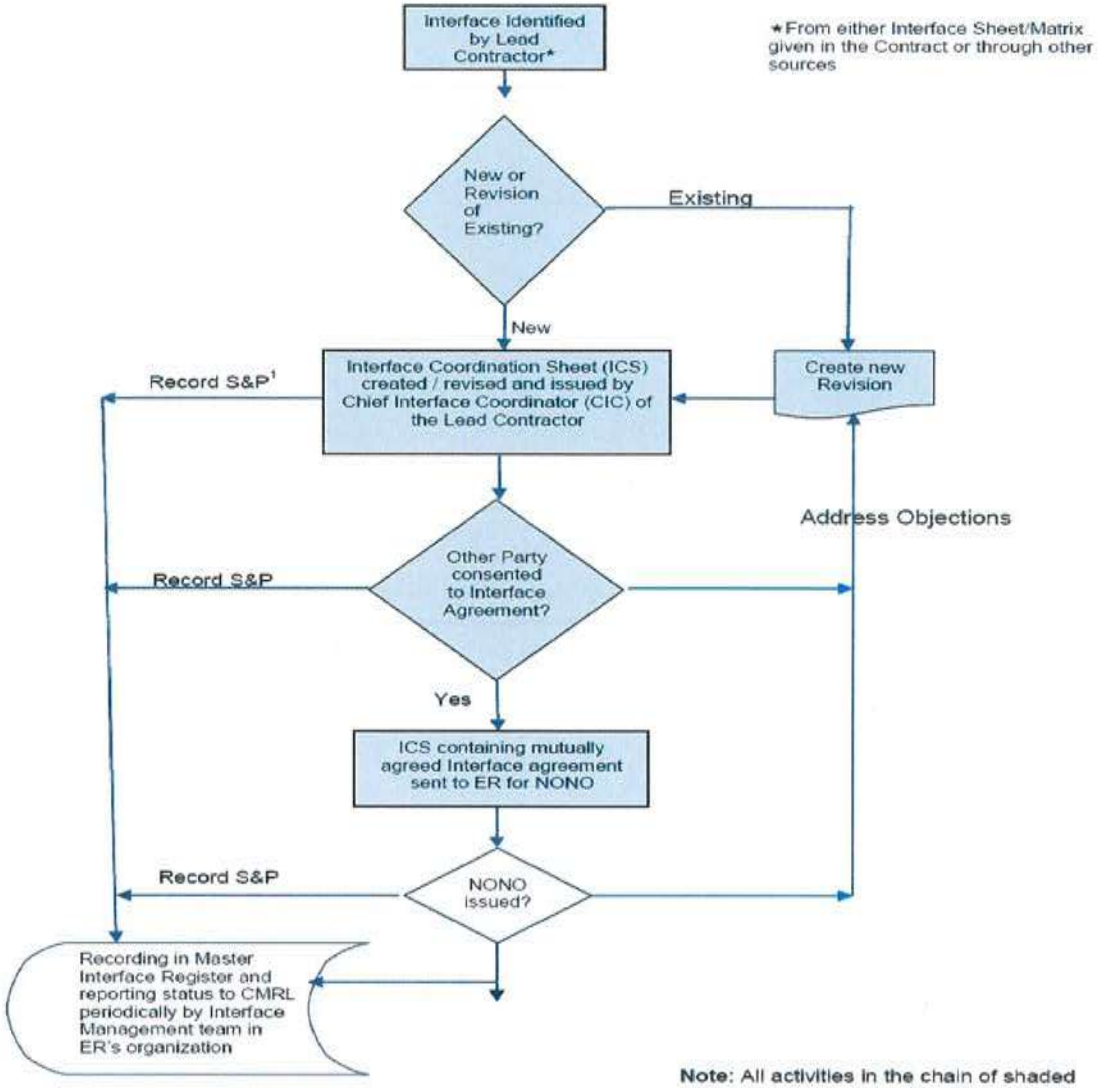
3.11 INTERNAL AUDIT FINDINGS

A	Location			Section		
	Date		**Internal Audit No.**		**Finding No.**	
	Name of Auditor			Standard		
				ISO 9001:2008		
				ISO 14001:2004		
	Name of Auditee			**BS OHSAS 18001:2007**		
				Relevant Clause No.		
	Non-Conformity		(Please make Tick [√] Mark as applicable)		Observation	

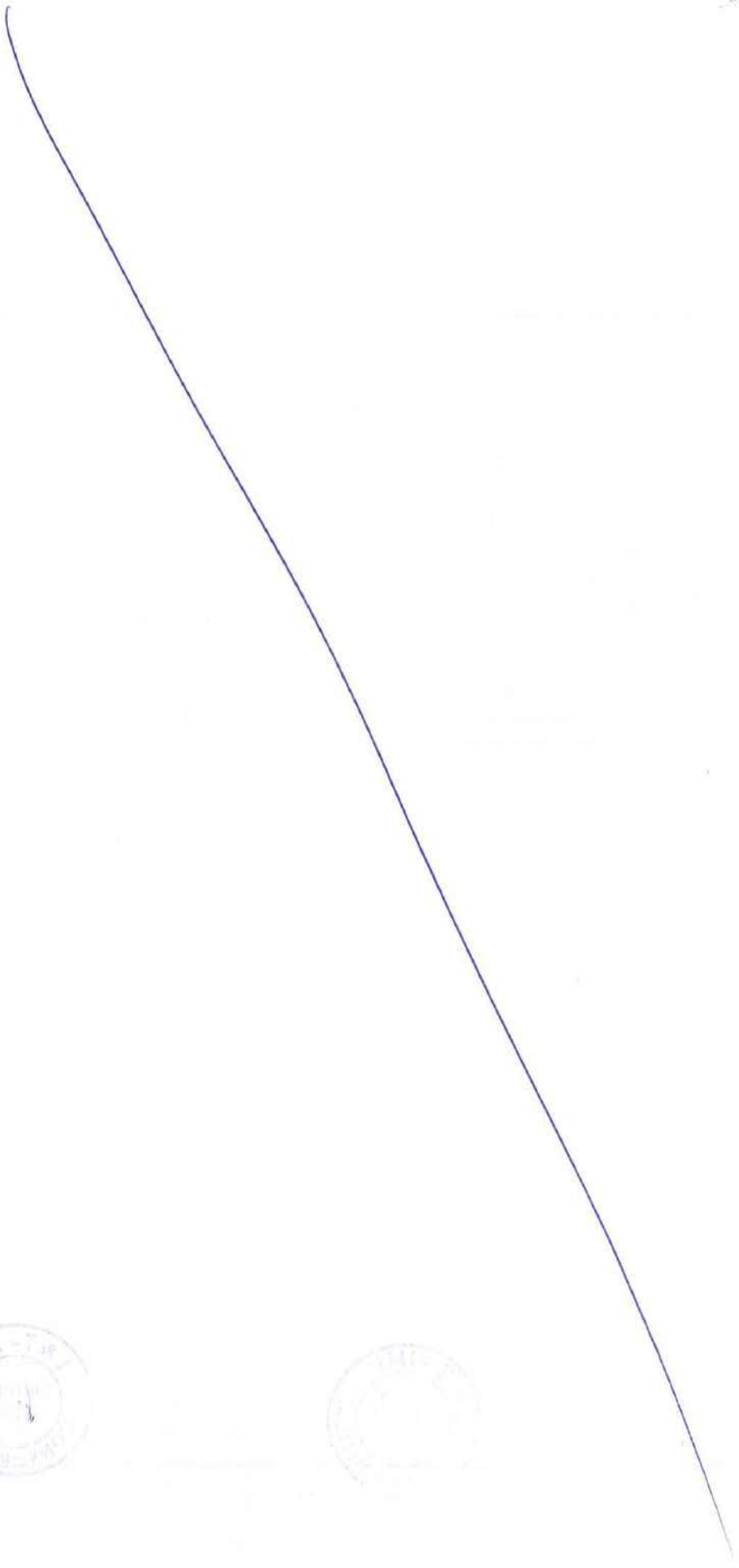
B	Details of Finding		
Root Cause (In Case of Non-Conformity)			
Auditor	x	Auditee	**X**
C	**Proposed Corrective Action and Proposed Completion Date**		
			X
			Signature
D	Verification(by Follow-up Auditor or	E	**Closure**
(Comments if any)	x Auditor		**Site Management Representative/Project In charge**



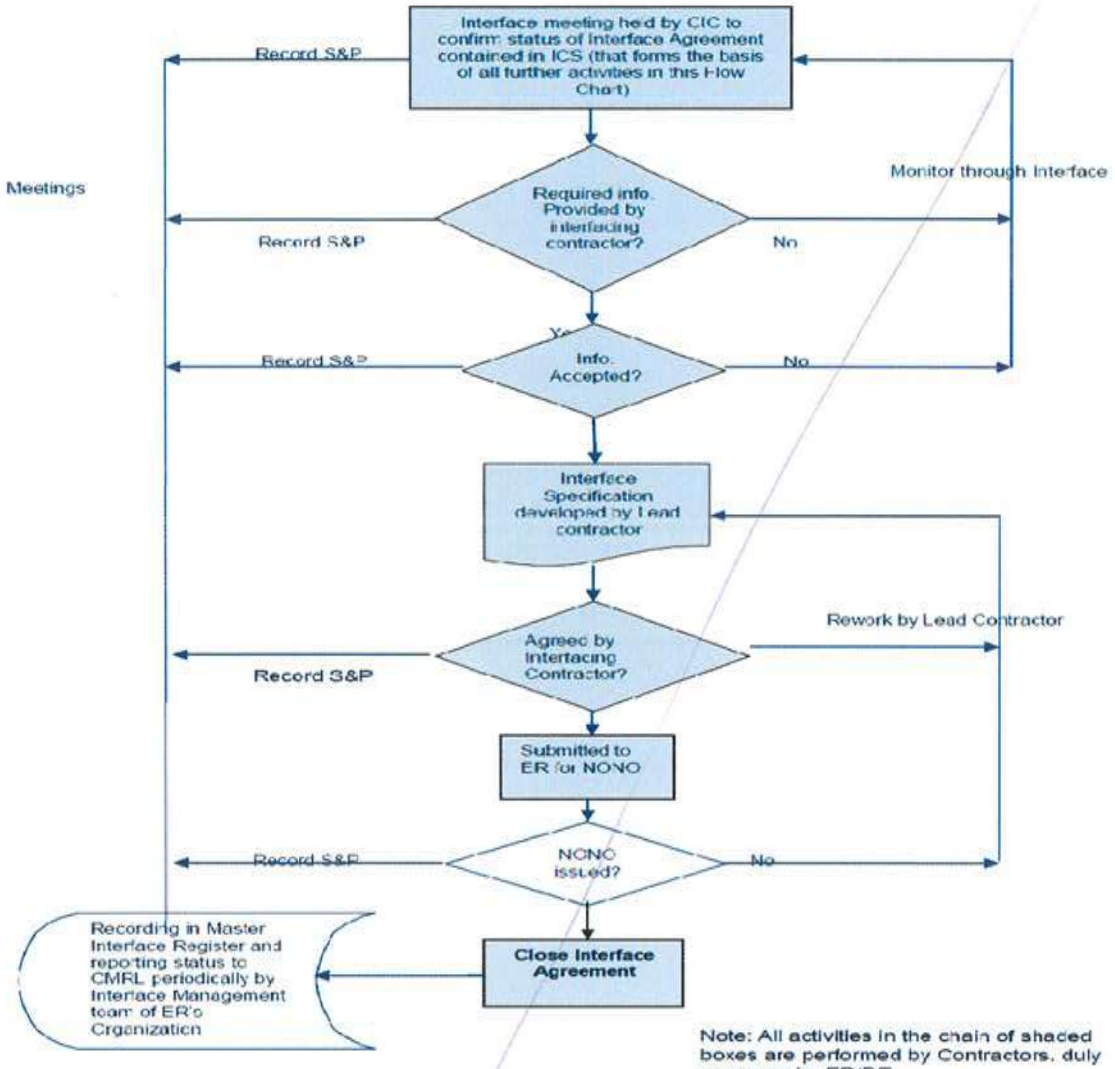
3.12 Flow Chart for creation / elaboration of Interface Coordination Sheet



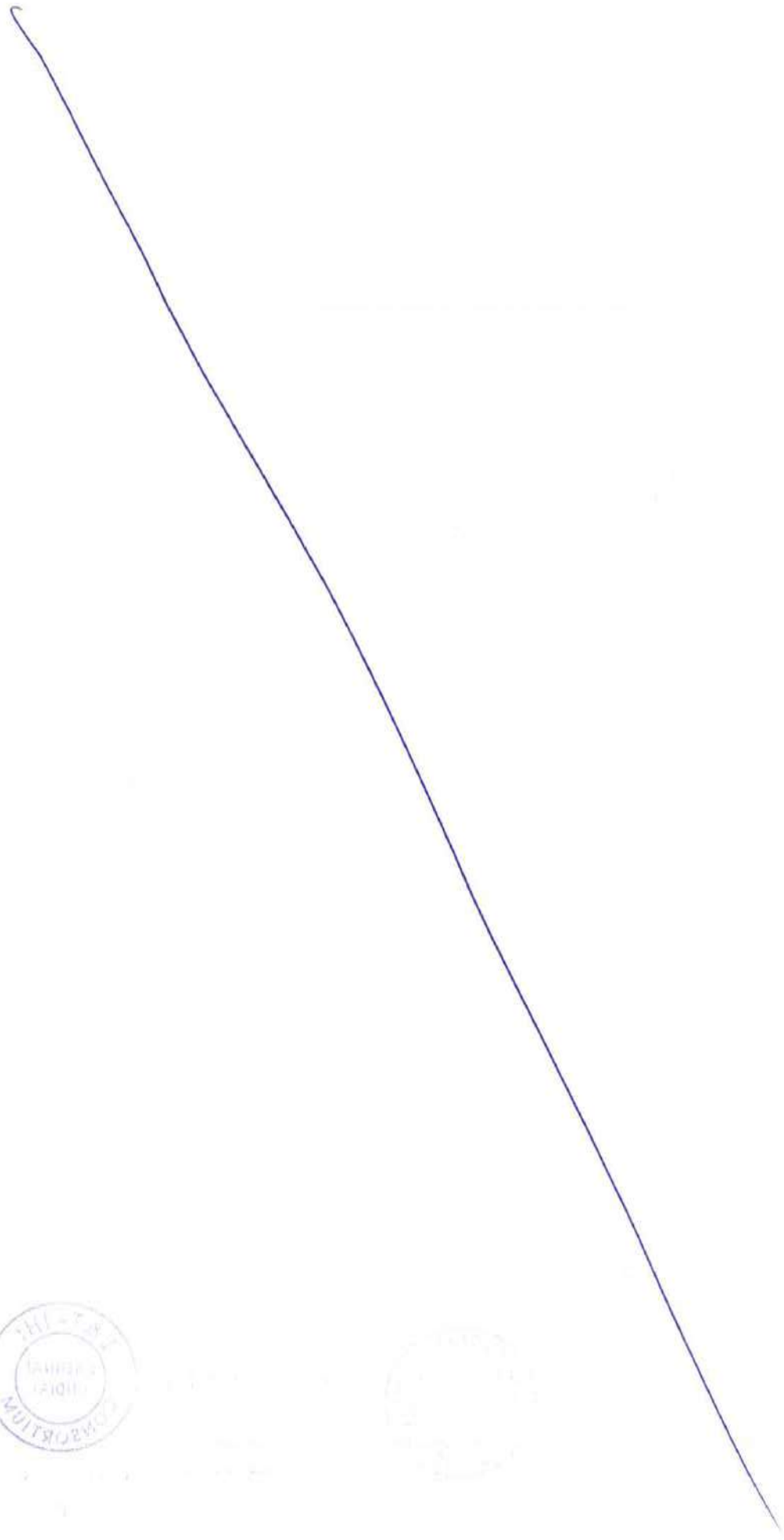
Note: All activities in the chain of shaded boxes are performed by Contractors, duly overseen by ER/RE.



Flow Chart for Progress Monitoring of Interface Agreements



Note: All activities in the chain of shaded boxes are performed by Contractors, duly overseen by ER/RE.



4. Documents and deliverables:

4.1 Interface Management Plan (IMP)

The Interface Management Plan is that document which describes contractor _____ interface management in terms of providing a clear description of each of the interfaces, both technically and sequentially, and represents an account of how the Contractor proposes to achieve co-ordination of the Works. The description shall completely detail contractor's _____ work scope and interface with each of the Interfacing Contractors in terms of technical description, sequence and timing for each of the elements required to achieve a coordinated design. contractor _____ Will demonstrates how potential interface conflicts can be eliminated by design simplification. This document is also required to demonstrate that the co-ordinate design and construction details described therein fully comply with the needs of others, and agreement in writing of these details by the Interfacing Contractors will be a pre-requisite to the Employer's Representative issuing a notice of no objection.

4.2 Interface coordinate sheets (ICS)

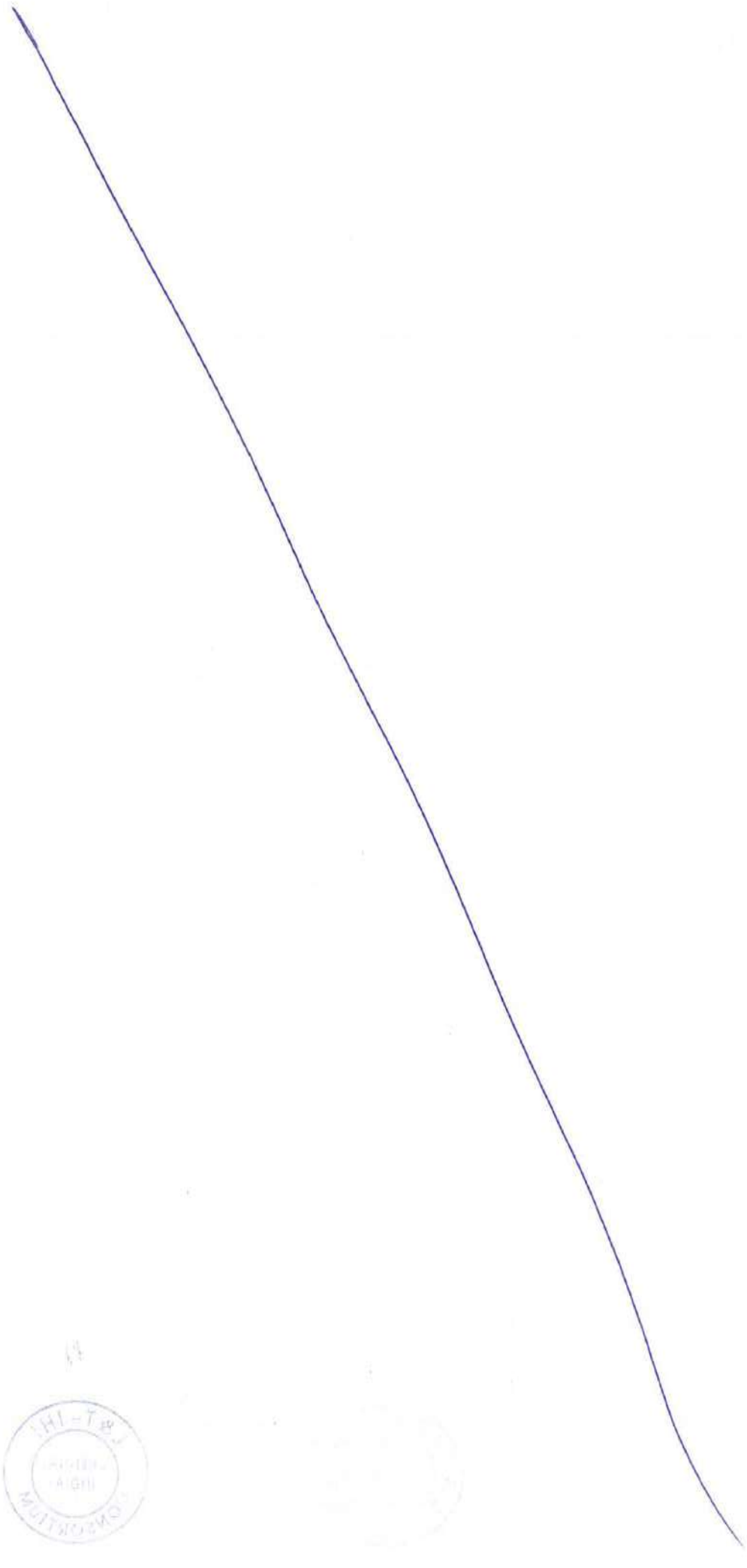
The Interface Coordination sheet, the common format issued by Engineers Representative is used to record all of the Contract Interfaces. contractor _____ shall ensure that each Interfacing Contractor provides their input and _____ contractor shall maintains the ICS continually update and submit to ER on monthly basis.

_____ contractor shall demonstrate their best co - ordination efforts as required by the Contract. To achieve this, the Contracts shall identify their interface requirements & exchanged regularly through the interface documents, i.e. IMP, IMPG, ICS, etc.

We shall monitor the ICS to ensure that, as the Interface progresses; the records show the appropriate Status as agreed with the Interfacing Contractors.

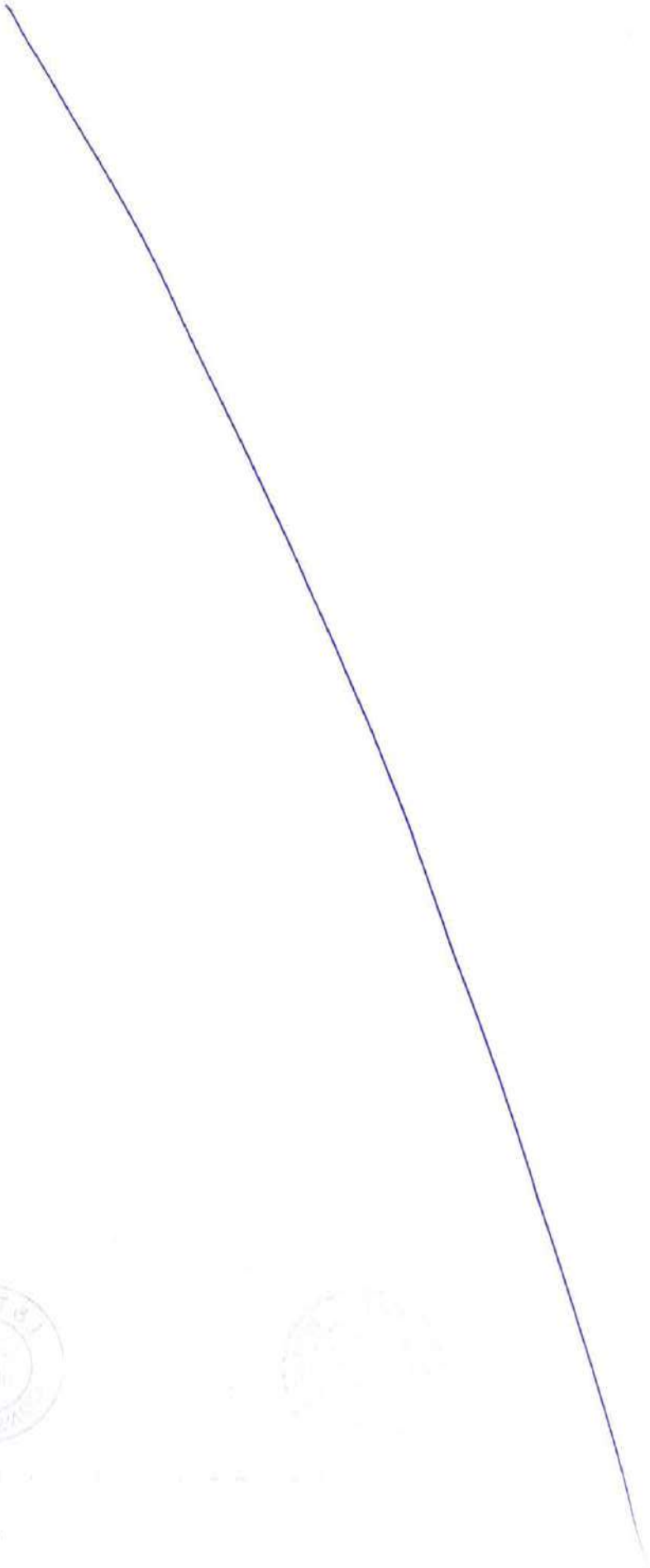
The Contractor _____ will be responsible for confirming the "Closing Out" of each ICS record, whilst ensuring that throughout the interface process all Interfacing Contractors have agreed to the following:

a) The receiving Interfacing Contractor has received and accepted the Interface being recorded.



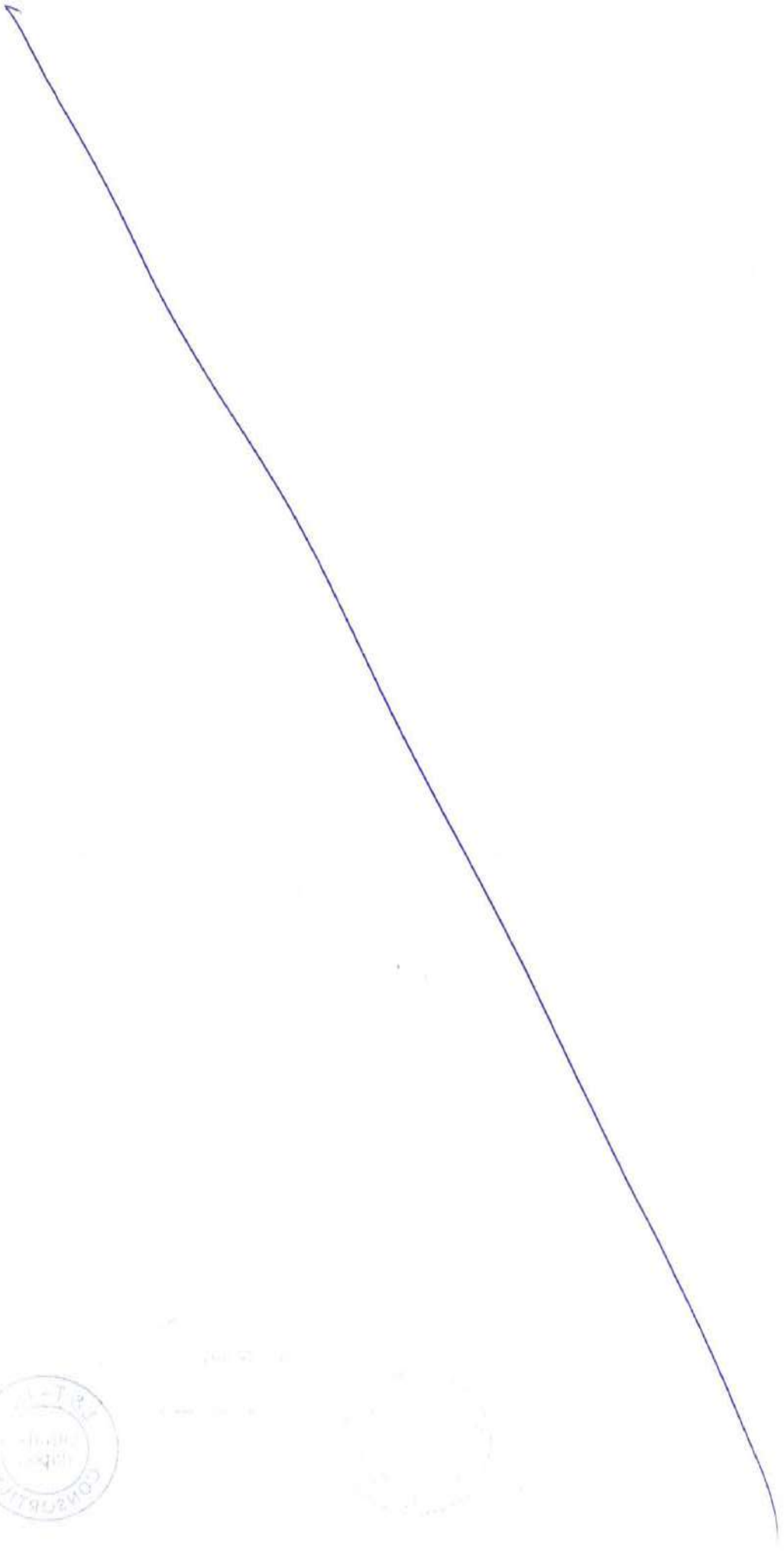
b) All Interfacing Contractors have recorded the interface record as "Proposed Close Out".
c) The Confirmation of Co-ordination form in Attachment has been updated and signed by the relevant Interfacing Contractors.

When documents are exchanged for review/comment with Interfacing Contractors, the originator these documents should ensure that they are accompanied by the Confirmation of Coordination form in Attachment. When the Interfacing Contractor returns these documents with comments to the originator, they should be returned with the Confirmation of Coordination form duly completed, confirming coordination and agreement or comment as appropriate, as a record of them having coordinated the interface item. This Confirmation of Co-ordination is to be transmittedto the Employer's Representative upon signing by the Interfacing Contractor



4.2.1 Interface coordinate sheets (ICS) Status indicator:

Interface Status Codes & Meanings		
Interface Status	Code for Log	Description of Status
To be coordinated	TBC	Both Contractors have not agreed the conditions for this interface
Coordinated	COR	Both Contractors have agreed that the interface is valid
Not coordinated	NCOR	One Contractor does not agree the conditions for this interface
Received	REC	The Contractor responsible for the design/construction element has received the information/documents required
Provided	PRO	The Contractor responsible for providing the information/documents to progress the design/construction element has provided the documents to the Interfacing Party
Accepted	ACP	The Contractor has accepted the proposed Interface Design or Construction element
Not Accepted	NACP	Either of the Contractors have not accepted the proposed Design/Construction element
Propose closeout	PCO	Both Contractors have accepted the proposed Interface Design or Construction element and no other requirements are outstanding. Both Parties can agreed to sign the Confirmation of Coordination Form
Closed out	CO	The final Interface Documentation together with Confirmation of Coordination Form has been sent to the Interface Coordination Manager for closing the interface
Superseded	SUP	The Interface design or construction element has been superseded



4.3 Interface Management Programme (IMPG)

The Interface Management Programme describes the sequencing and timing of each of the Interfacing Contractors" scope of work, clearly describing the interdependencies for all stages of the work between the works and that of the Interfacing Contractors and complementing the Interface Management Plan, whilst complying with all Key Dates

The programme shall be structured to detail each of the primary zones of interface and the principal elements of the design and of the works requiring interfacing contribution from others. This Interface Management Programme shall also be related to the Works Programme and shall show the sequences and timing agreed with the Interfacing Contractors to the necessary degree of detail to clearly illustrate each of the interfaces to be undertaken.

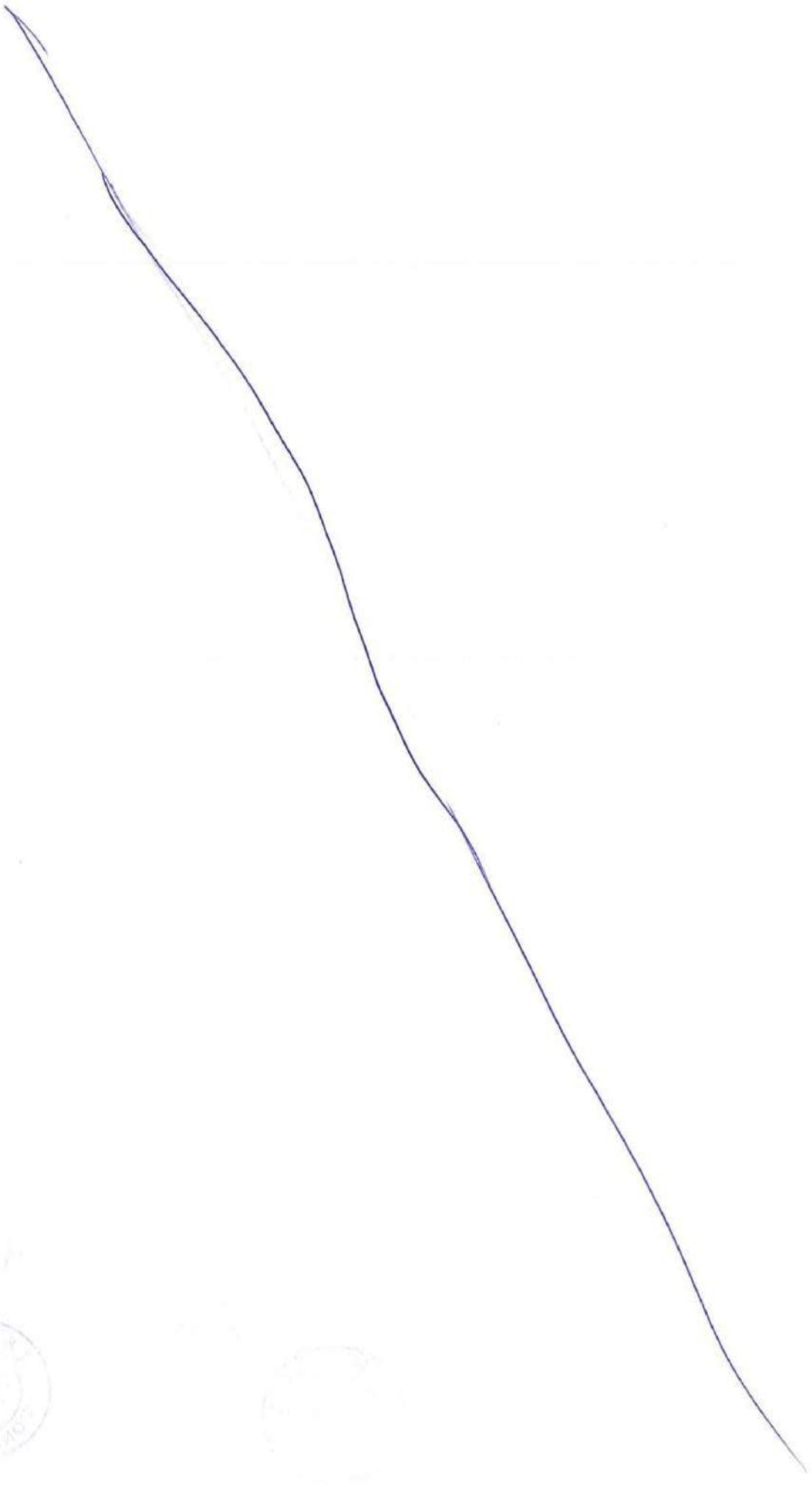
Targets to receive or supply information shall also be shown, with due allowance being given for the design process of others. Information relating to Contractual Key Dates and information exchange dates shall be shown for both the Contractor and the Interfacing Contractors to demonstrate a matching of design processes.

A record of these interfaces, with current status and agreed dates for information transfer, site inspections, access, occupation, handover, etc. Shall be maintained and also identified on the ICS.

4.4 Interface Specification.

The Interface Specification, and associated drawings shall specify the proposed method and schedule for verifying the interface integrity, the individual equipment/system performance and the combined system performance.

The Interface Specification shall include a programme of tests to demonstrate the performance and integrity of the integrated system. The interface sheets developed by the Employer's Representative . The attached interface sheets are not final and do not relieve our obligation to identify any new interface to meet contract requirements. The interface sheets, which the Contractor shall develop, shall be used as a basis to establish the Interface Specification. Any revision to the Interface Specification shall be mutually agreed between the Contractor and Interfacing Contractors, with submission to the Employer's Representative, and shall specifically -



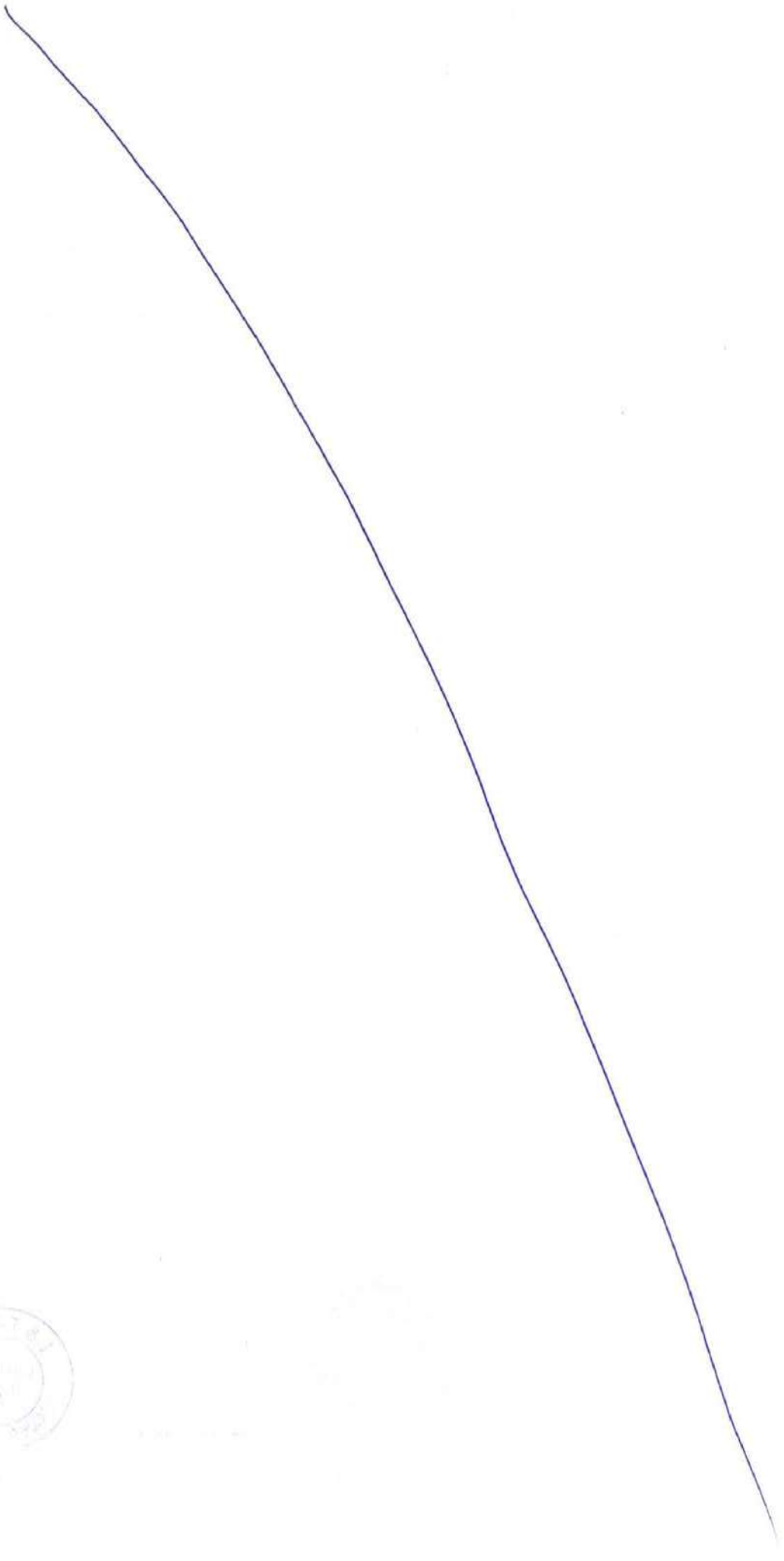
- Understand the design requirements of each party and associated constraints;
- Determine the detailed interface works to be performed during the various stages and
- Agree on the interface works in reference to respective scope, with any agreements reached to be formally documented in Interface Meeting Minutes, including an actions item list.

The Interface Contractors shall mutually identify and agree the Interfaces that will exist between them using the Interface Coordination Sheets, the format of which is contained in Attachment F. These interfaces may be expanded to include all, and any other, interfaces that develop during the execution of the Project.

The Interfacing Contractors shall mutually agree upon the information to be exchanged and shall develop a unique Interface Specification for each interface identified. A sample Interface Specification Performa is provided in Attachment C.The ICSs will be tracked and monitored using an ICS Register to be compiled by the Contractor. This register will track the progress of the ICS from inception through to closure and final processing by the Contractor, prior to transmittal to the Employer's Representative as a complete Integrated Design.
Each interface shall have a unique reference number to enable the Interface to be readily identified and tracked and monitored

4.4.1 Interface Specification format:

	Contract Designation	Contractors Sequence Number	Date of Issue	15/09/ 2008
Initiating			Interface Manager Signature	
Responding			Interface Manager Signature	
Interface Specification Required for;			**Response Required by;**	
Reviewed by; Design Sections				
	Civil Work	**Track work**	**Station Arch. / Building Services**	Core Systems
Description of the Interface				
Specific Details of the Interface				Location
Drawings / Specifications Attached				
Title		**Drawing / Specification Ref.**		Drg. Issue
Document	**Name**	**Date**	Document References (if any)	
Prepared by:				



5 Drawings, forms and formats

5.1 Coordination drawings

For the purpose of achieving a Project which is fully co-ordinate with respect to civil, structural, architectural, building services, electrical, mechanical works and interface elements, and to ensure compatibility between different facilities and services, and adequate space requirements, all drawings shall be reviewed and co-ordinated.

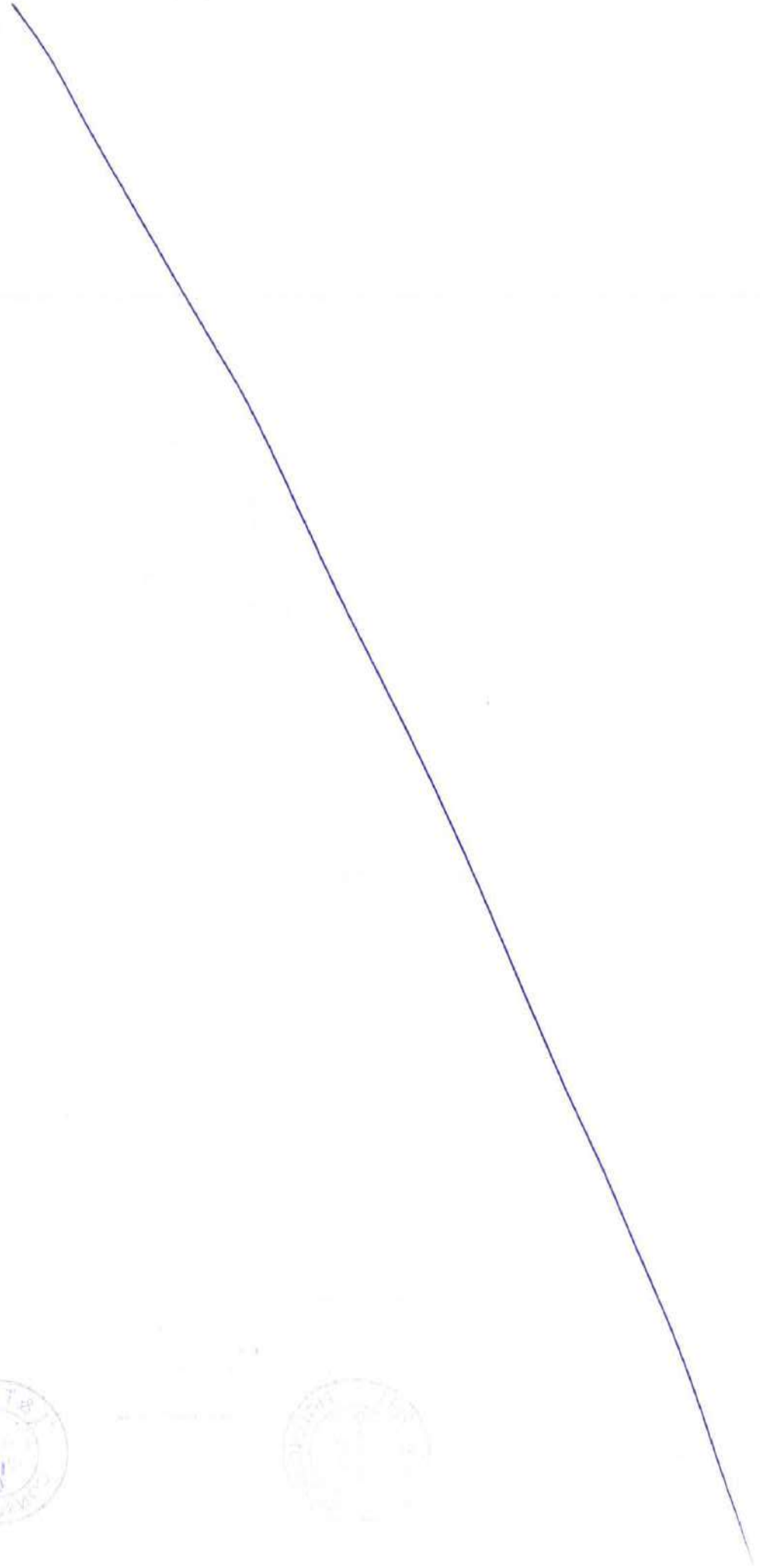
The detailed Interface Working Drawings in terms of items such as; special arrangements, space allocation, cast in items, primary and secondary fixings, grouting of equipment/plinths, drill and fix brackets, embedded and cast-in items and the like.

The drawings shall be prepared and shall also include composite cross-sections and layouts, which show the spatial requirements of all Interfacing Contractors and identify items shall be finalized, defined, or resolved & recorded with due NONO from Engineers Representative.

5.2.1 Combined Services Drawings (CSD)

The CSDs will be clear and sufficiently detailed to unambiguously show the intent of the subject services and the corresponding structure / facility allowances. While these drawings do not have to duplicate all of the details of the Drawings, they will include plans sections and elevations as required to clearly illustrate the compatible relationship between the different disciplines. Specifically, the drawings will include wall elevation drawings at 1:50 scale (or larger where required) indicating all openings, access panels, reinforcement zones, embedded and cast-in items and the like, and shall be submitted to the Employer's Representative for a notice of no objection.

The CSDs shall show the intended locations, routes and spatial relationships of the individual E&M services, Building Services systems, and installations, Core Systems installations and other installations, fully co-ordinate with each other and the civil structural and architectural work. The CSDs shall also clearly indicate that effective cable co-ordination has been achieved in terms of cable location or cable trays and the trunking and cable routing.



5.2.2 Structural Electrical & Mechanical Drawings (SEM)

The SEMs shall show all civil, structural, and architectural requirements for the E&M services, Building Services systems and installations, Builder's works and the Core Systems and other installations.

Where Builder's works are required by the Interfacing Contractors, the drawings, details, specification notes and catalogue information and the like shall be obtained by the Contractor from these Interfacing Contractors indicating the builder's work to be incorporated into the Works. The Contractor shall include details of such Builder's works in the SEMs and Method Statements as appropriate.

Builder's work comprises, but is not limited to, the following:

- Construction of plinths, bases, builders bund walls and the like.
- placing and fixing of holding down bolts, lifting beams and hooks and other supporting items;
- supply, fabrication installation, protection, fixing and finishing of supporting steelwork, for equipment and associated accessories;
- casting in of edgings, angles in recesses, ducts, conduit, pipes etc;
- fixing equipment and associated, brackets, cable containment and fixtures;
- forming of penetrations, sleeves, access panels, holes, chases, recesses, openings;

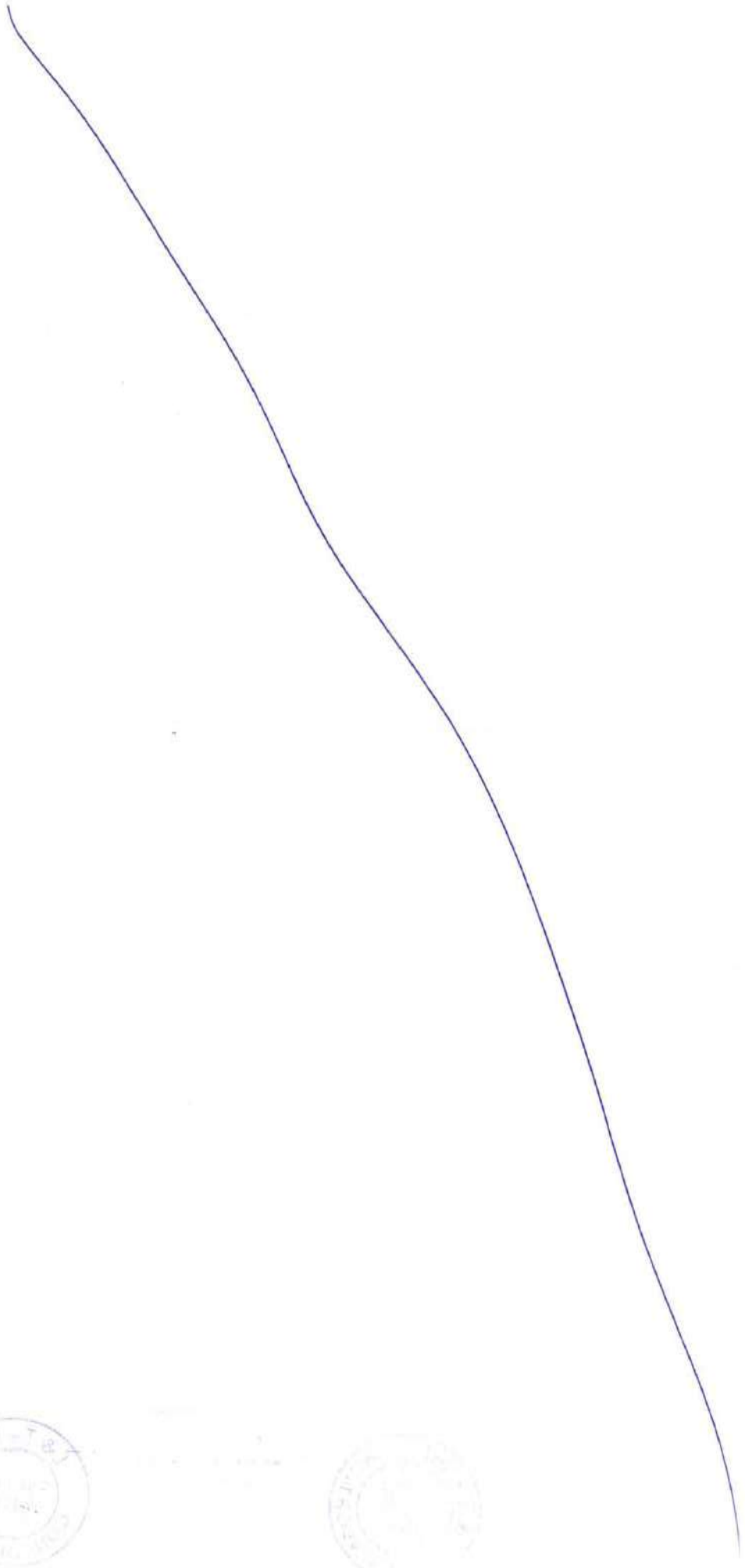
All in accordance with the Contract.

The CSD/SEMs shall also be used for the purpose of co-coordinating with the Interfacing Contractors and shall be continuously updated to reflect the latest interface co-ordination. Copies of the CSD/SEM drawings shall be included in submittals to the Employer's Representative.

Where the CSDs or SEMs do not fully co-ordinate with the Site conditions the Contractor shall co-ordinate and propose a solution to the problem. All proposed solutions shall be issued to the Employer's Representative.

5.3 As Built drawings

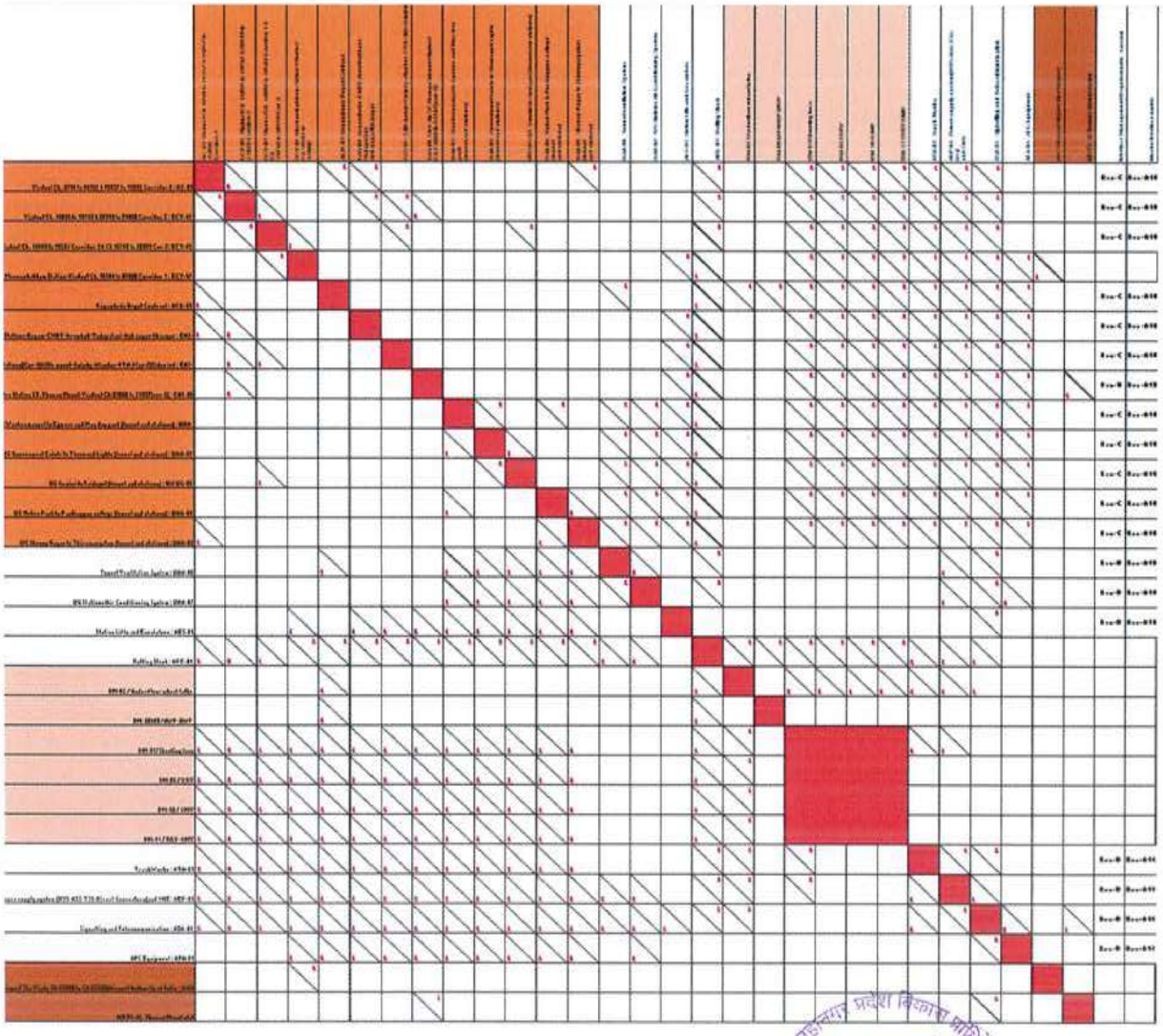
Upon completion of the Works all Combined Services Drawings, Structural E&M Drawings, and Interface Demarcation Drawings will be submitted to ER showing the final "As Constructed" status of the Works related to these drawings.



5.4 Interface Drawings

The interface drawings shall be prepared in diagrammatic format for each interface. The drawings shall be submitted to ER for notice of no objection. The predesigned interface drawings mentioned in Volume 6 of the tender shall be used as basic reference & further developed & submitted to Engineer's Representative for notice of no objection

5.5 Master Interface Matrix



5.6 Confirmation of Coordination Form

		Ref No.
	CONFIRMATION OF COORDINATION	
CONTRACT:		TRANSMITTAL No.:
TITLE:		
ACTIVITY NO.:		
GENERAL DESCRIPTION:		

SIGNATURE OF INTERFACING CONTRACTORS:

	Interfacing Contractor	Authorized Name	Signature	Date Reviewed	Comment
1					
2					
3					
4					
5					

Signatures above confirm that this design document has been reviewed as part of the coordination process.

NOTE: **Where Contractors are not in agreement with the details on this submission, they are to comment above and advise the interfacing party in question requesting accommodation of the requirement and advise the Employer''s Representative under separate cover and report progress in Monthly Report / Coordination Meetings.**

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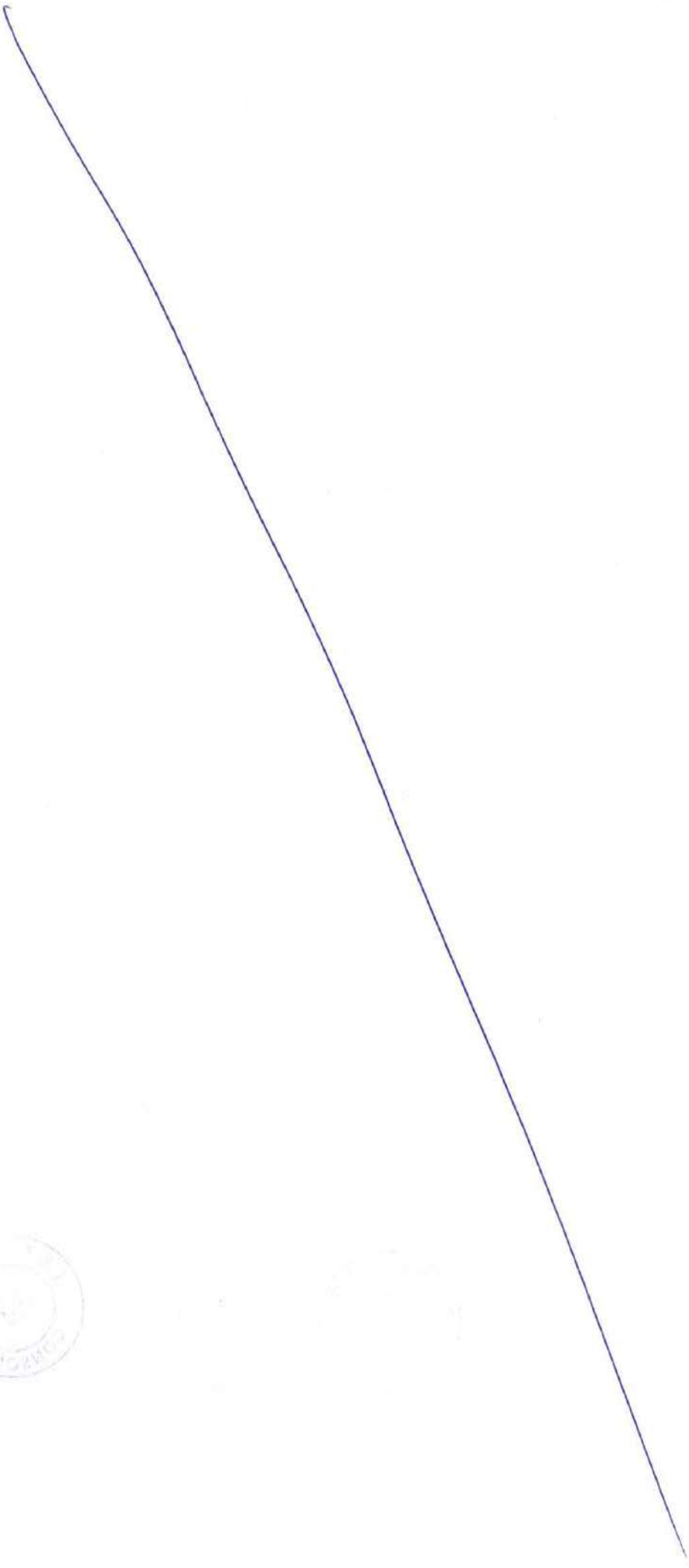

6 Interfacing stake holders

S.	Interface Scope	External Entities.
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

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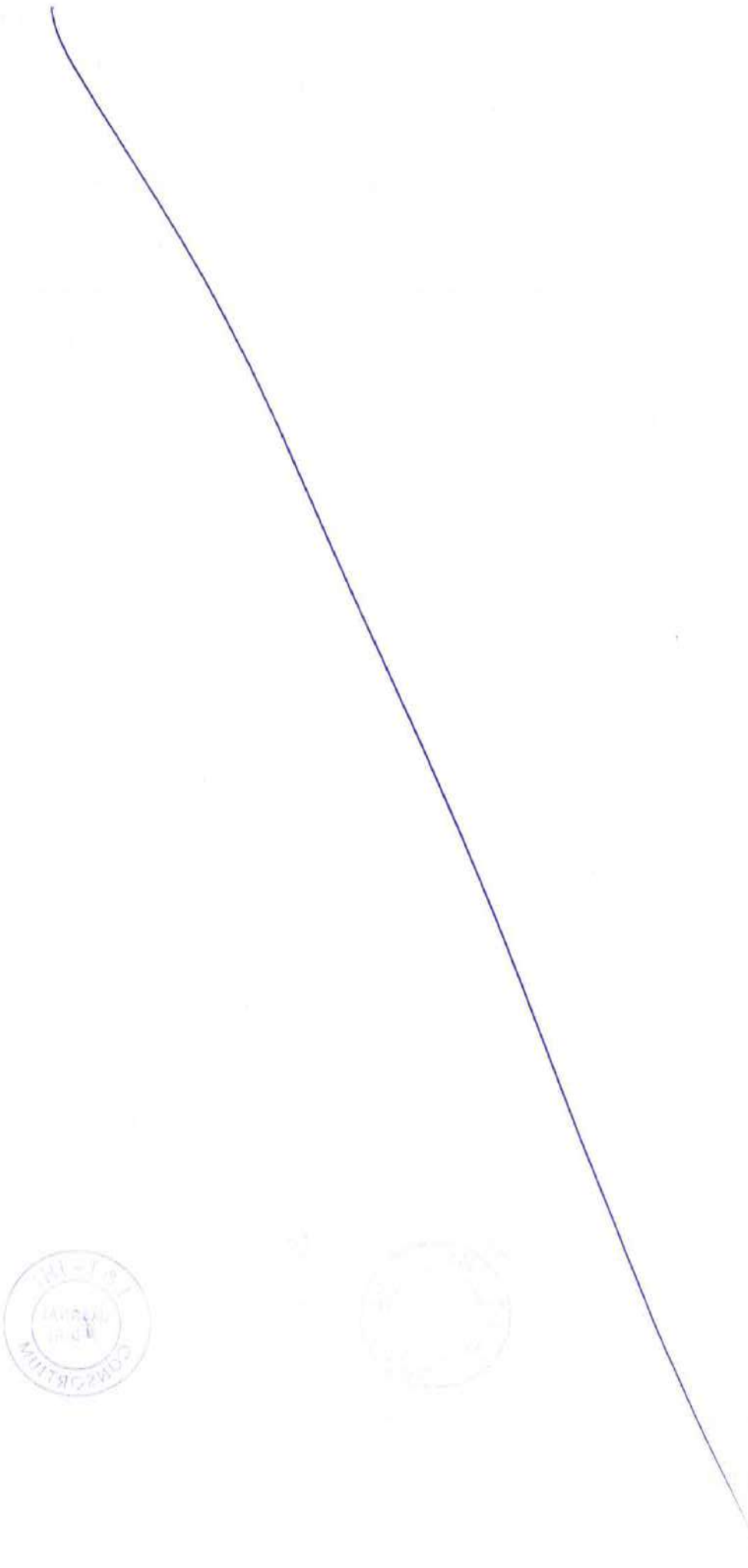
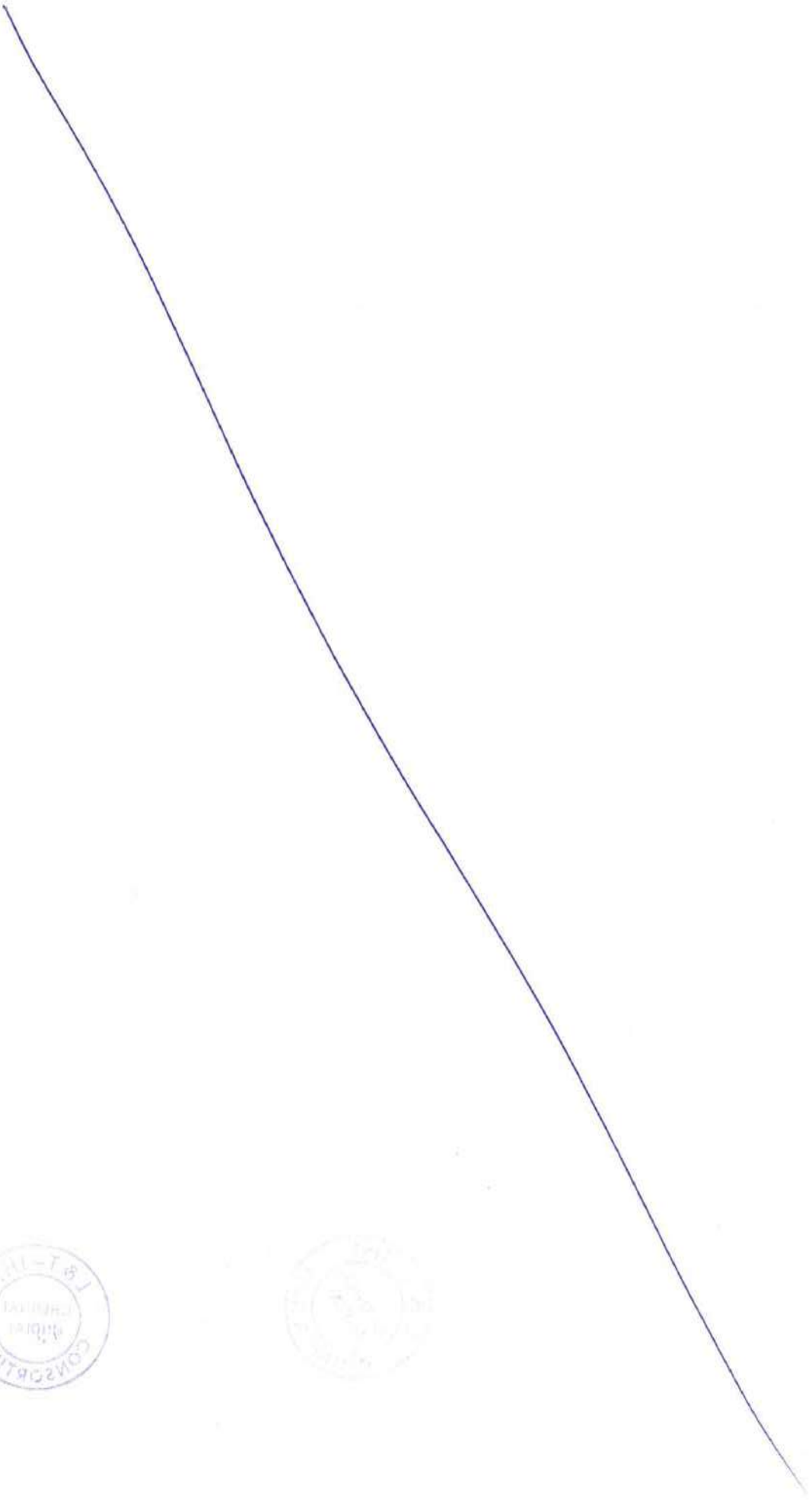
L&T - IHI CONSORTIUM CHENNAI (INDIA)



Quality Assurance Plan

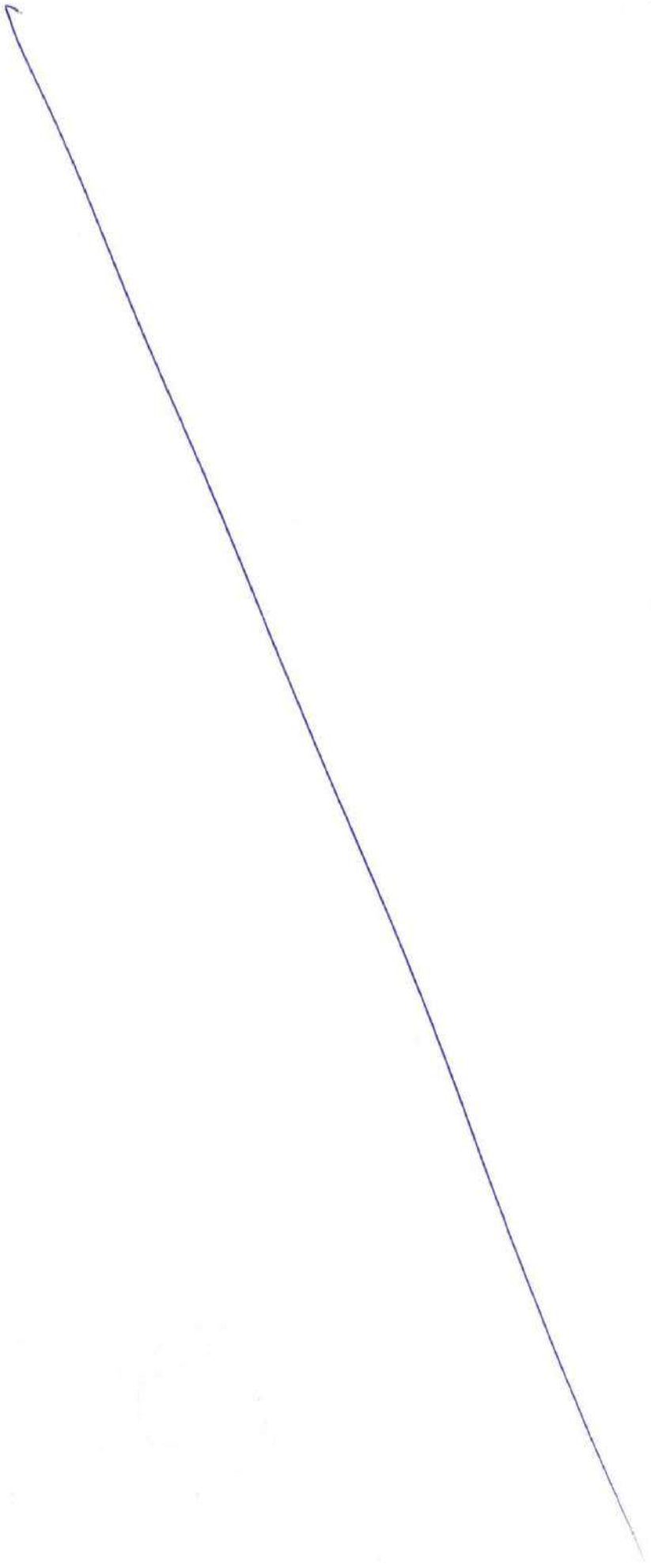
6.1 interfacing stake holder's contact details:

Organisation / Contract Package	Position	Name	Contact No	Email

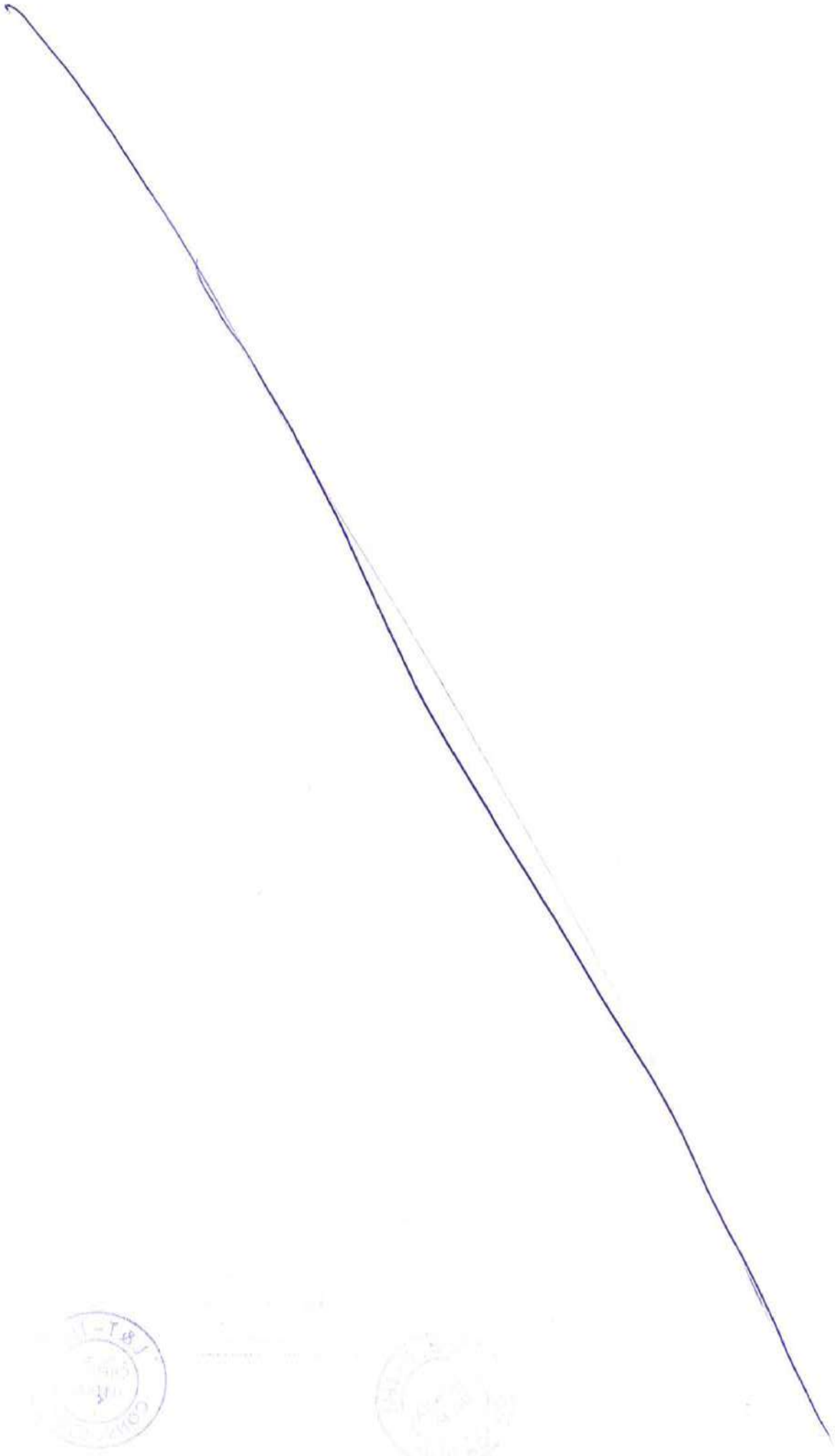


7 Annexure I Interface key points

ANNEXURE I		
InterfaceKeyPoints-ContractPackageNo< >		
PROVISIONS AS PER THE INTERFACE SHEET		
Interface Item Reference No	**Lead Contractor**	Follower Contractor
DESIGN		
CONSTRUCTION / INSTALLATION STAGE		
TEST & COMMISIONNING STAGE		



MAINTENANCE STAGE		
	NIL	**NIL**
DESIGN STAGE		



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Quality Assurance Plan

BU:
Department

Sl. No	Type of Document	Description	Minimum retention period
1	Policy matters	Management Circular on Participation in tenders	Permanent
2	Tender	Notice inviting tender (NIT)	Five Years
		Tender Document	Five Years
		Unsuccessful Tender Document	Five Years
		Successful tender document	10 Years
		Letter of Intent (LOI)	10 Years
		Signed contract	10 years
3	Plans and specifications(such as statements of requirements, operational requirements, technical plans, resource plans)	Tender Stage	Till completion of Project
		Final	ten years after completion of project
4	Contract operation and monitoring	Reports from contractors	Two years from end of contract
		Schedules of works	Two years from end of contract
		Bills of quantity	Five years from end of
		Surveys and inspections a. equipment and supplies b. buildings	Two years from end of Contract.
5	Amendments	Changes to requirements	Five years

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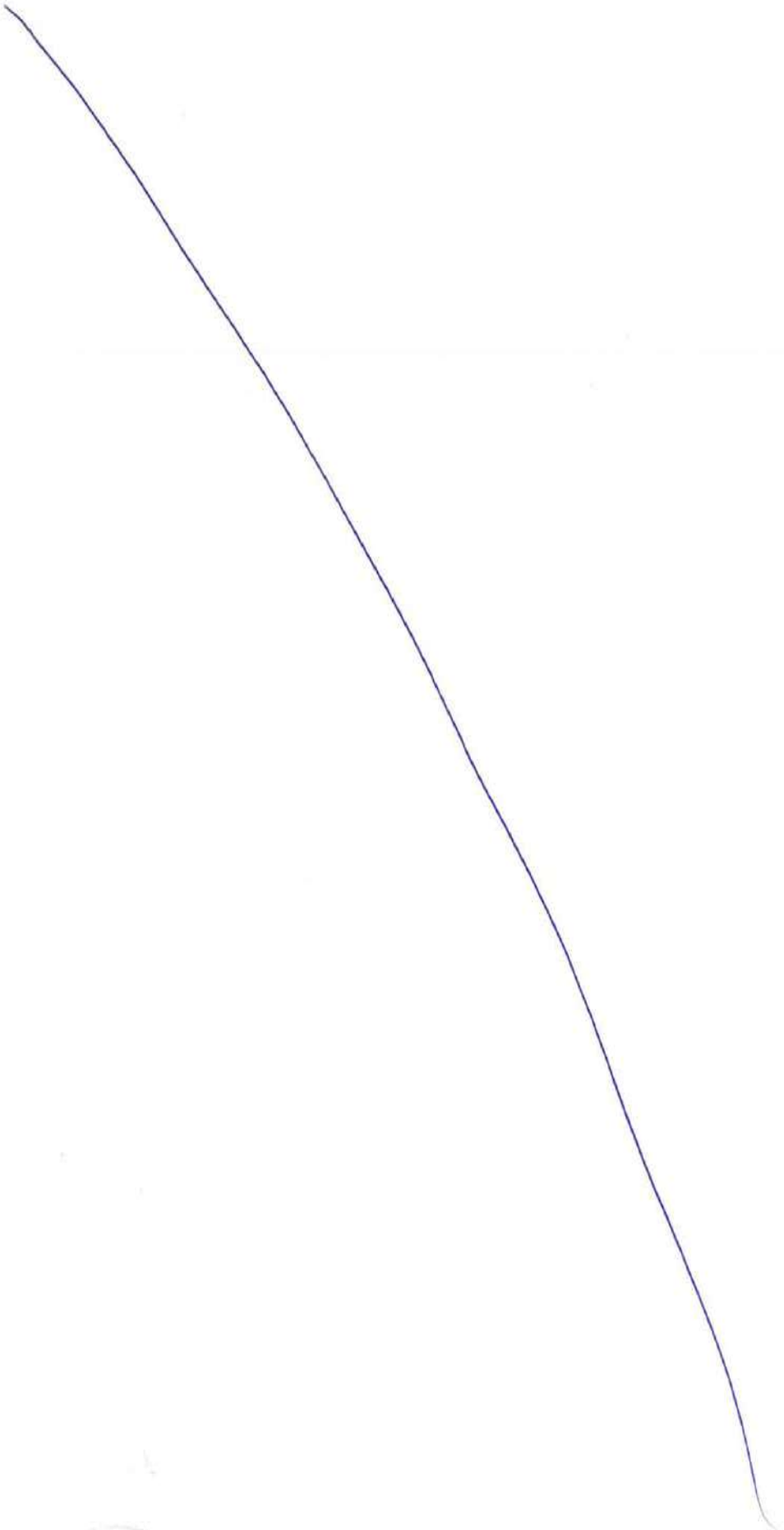
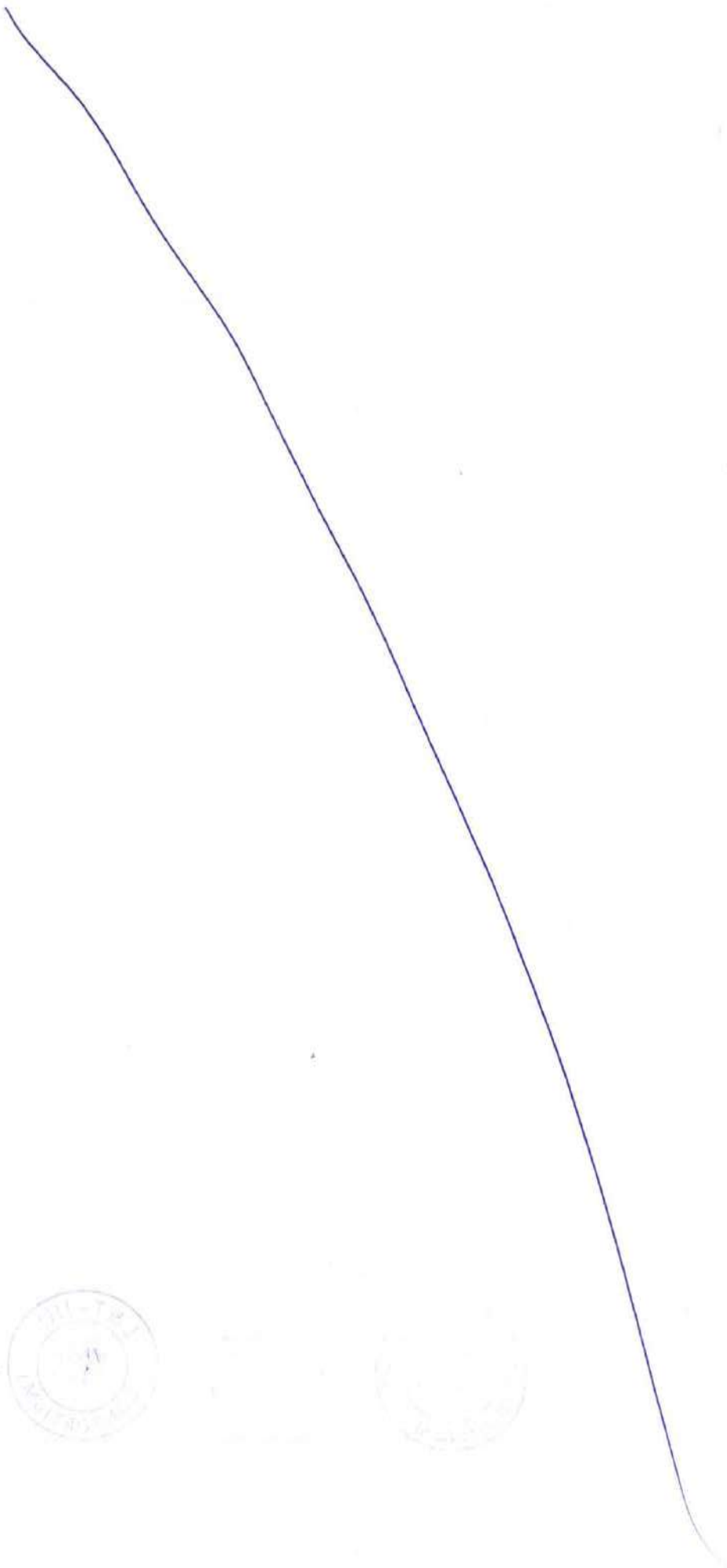


			from end of contract
		Extensions to contract	Five years from end of contract
6	Operating manual/ As per drawings	-	Five years after completion of project
7	Operating Manual/ Documents	-	Permanent
8	Plans and specifications (such as statements of requirements, operational requirements, technical plans, resource plans)	variations	ten years after completion of project
9	Miscellaneous records such as	Copies of documentation from other projects; information on products, equipment or machinery; training courses; correspondence	Two years after completion of project
10	Amendments	Forms of variation	Five years from end of contract
11	Project operating manual	Operating manual, Build Drawings & Contract Document	Permanent
12	Operational quality documents	Methods statements & ITP's	Till completion of Project



Quality Assurance Plan

Handing over of Documents

OBJECTIVE: The guidelines for handing over of Documents and Responsibilities to other personnel.

SCOPE: All activities at Site and office.

APPLICABILITY: The following are the cases as per the requirement.

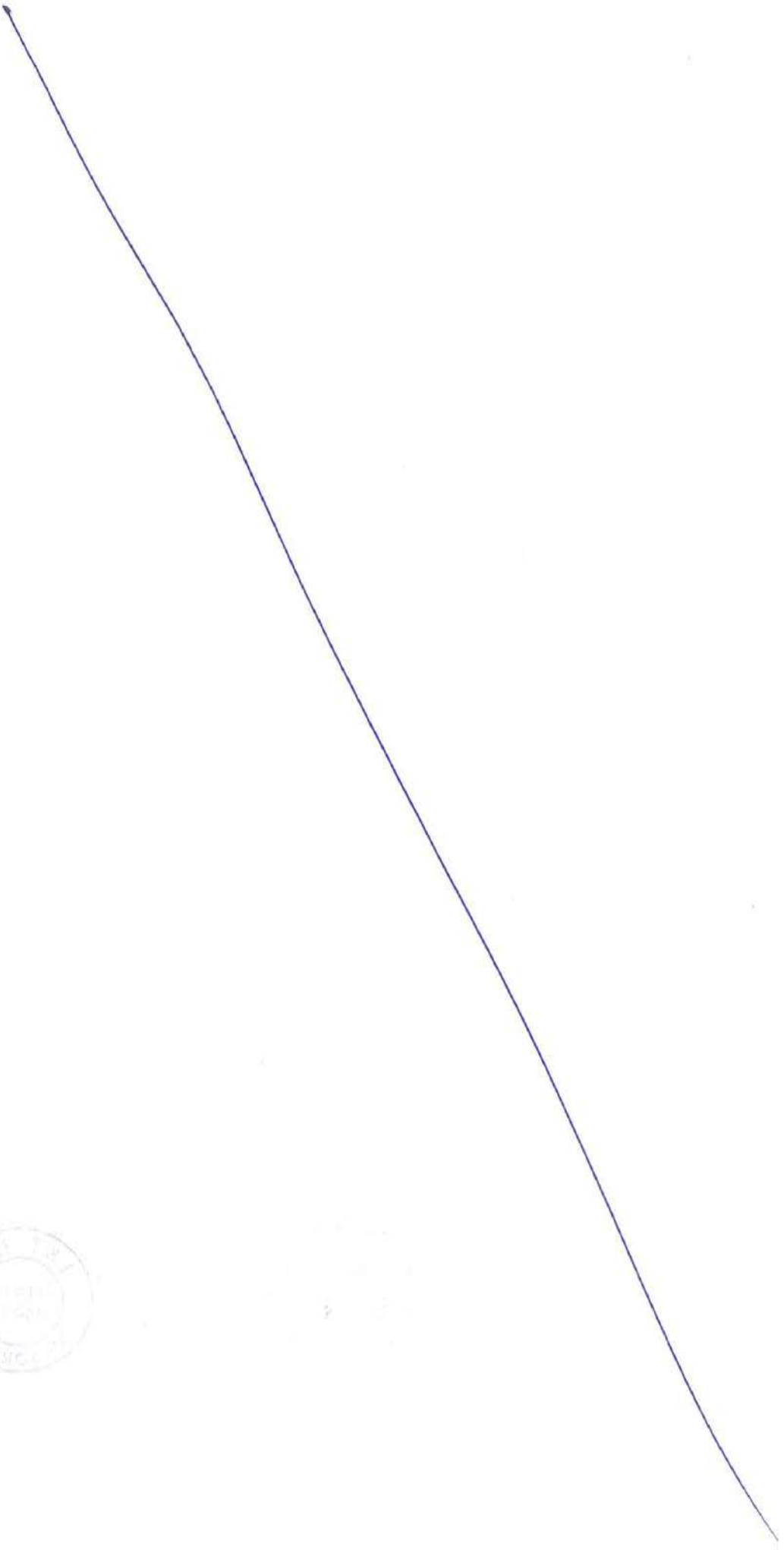
a) Transfer of person to other site/office/other dept.
b) Long Leave/ absence from work
c) Merge/Splitting/Reconstruction of Department.
d) Resignation of personnel.

PROCEDURE:

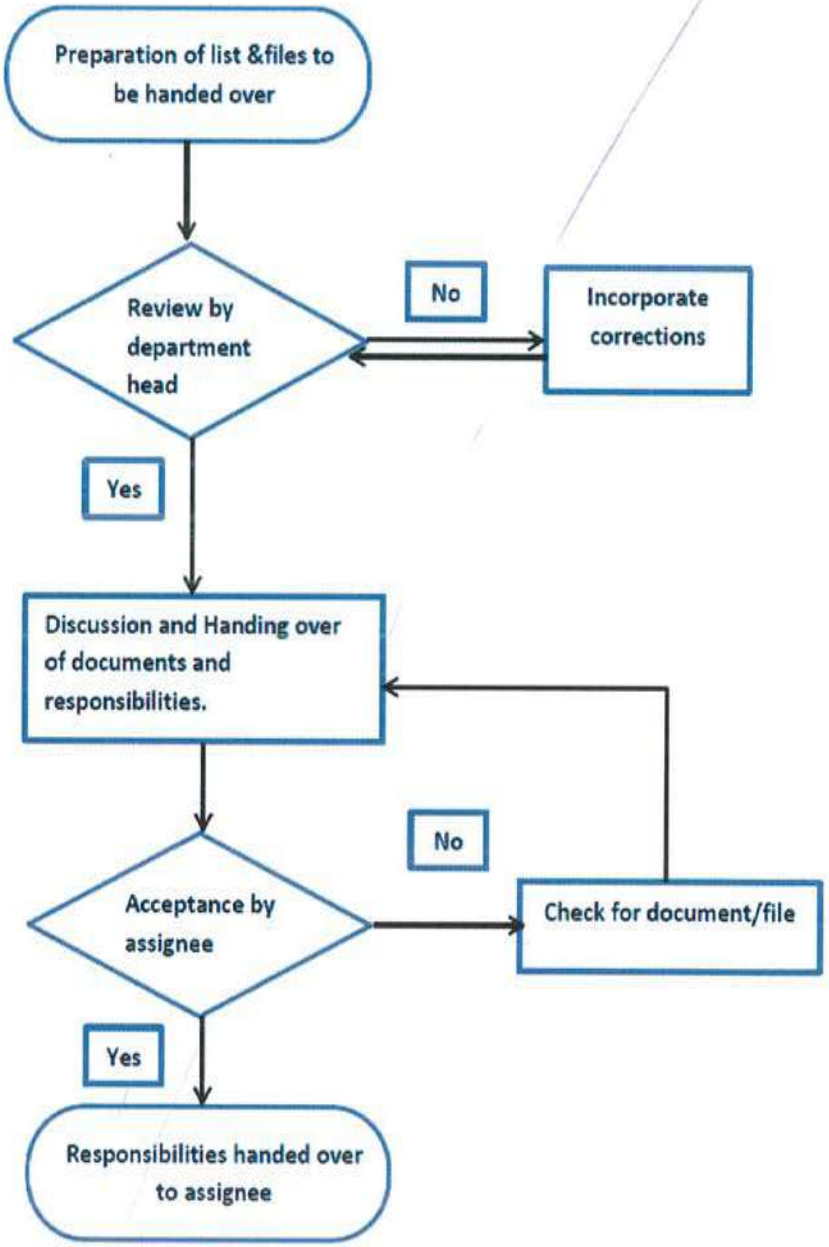
1. Prepare a list of documents to be handed over, with document details.
2. Create Folder/ File and update it.
3. Documentation files must be labelled for easy identification and specify location of File docket or hardcopy or soft copy.
4. After preparation get it reviewed by Department-Head for changes, if any.
5. Explain and handover to the concerned.
6. Create suitable record for concurrence for mutually agreed document.

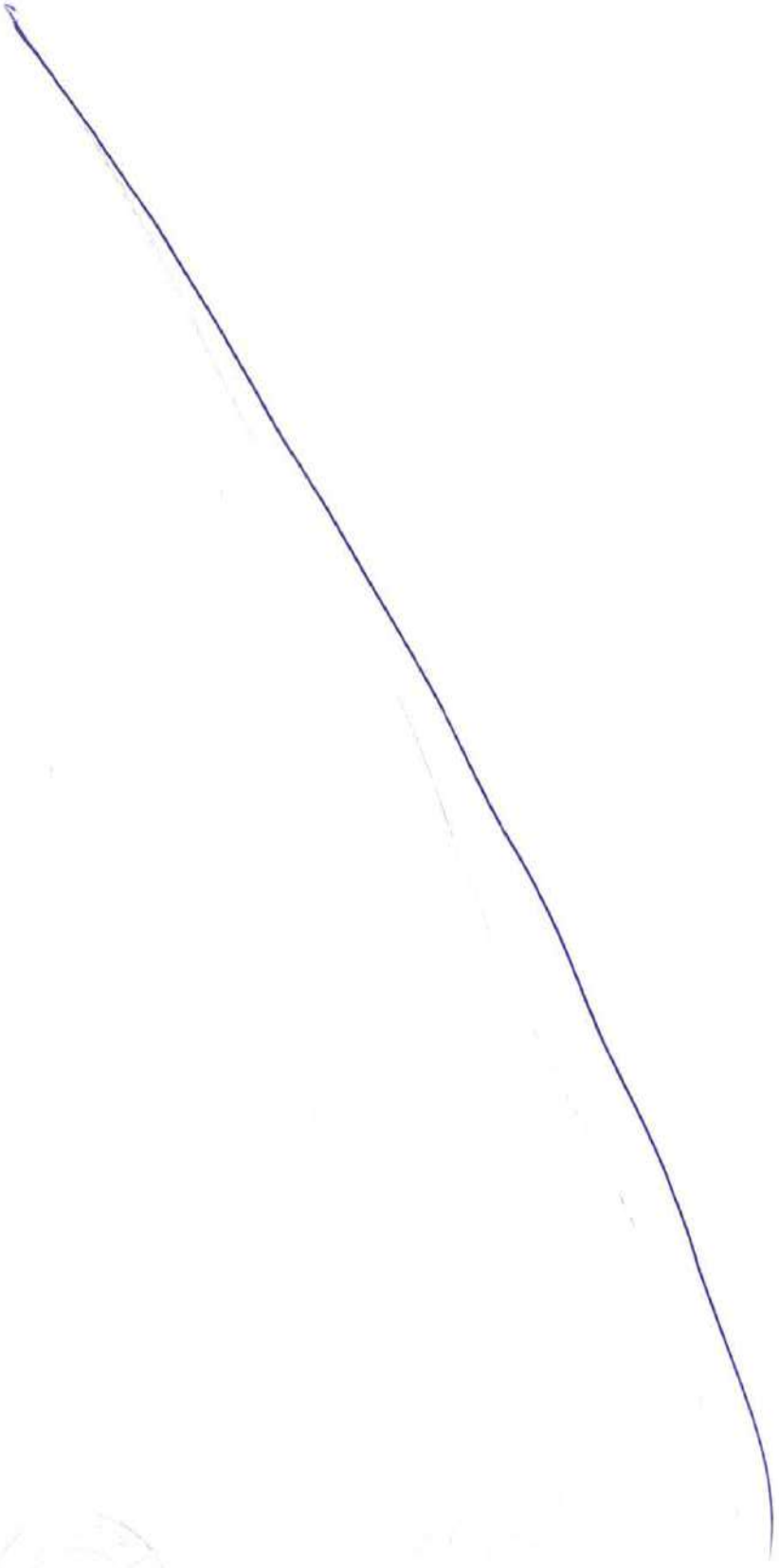
RECORDS:

1. Record of Handing over



Process Flow Chart



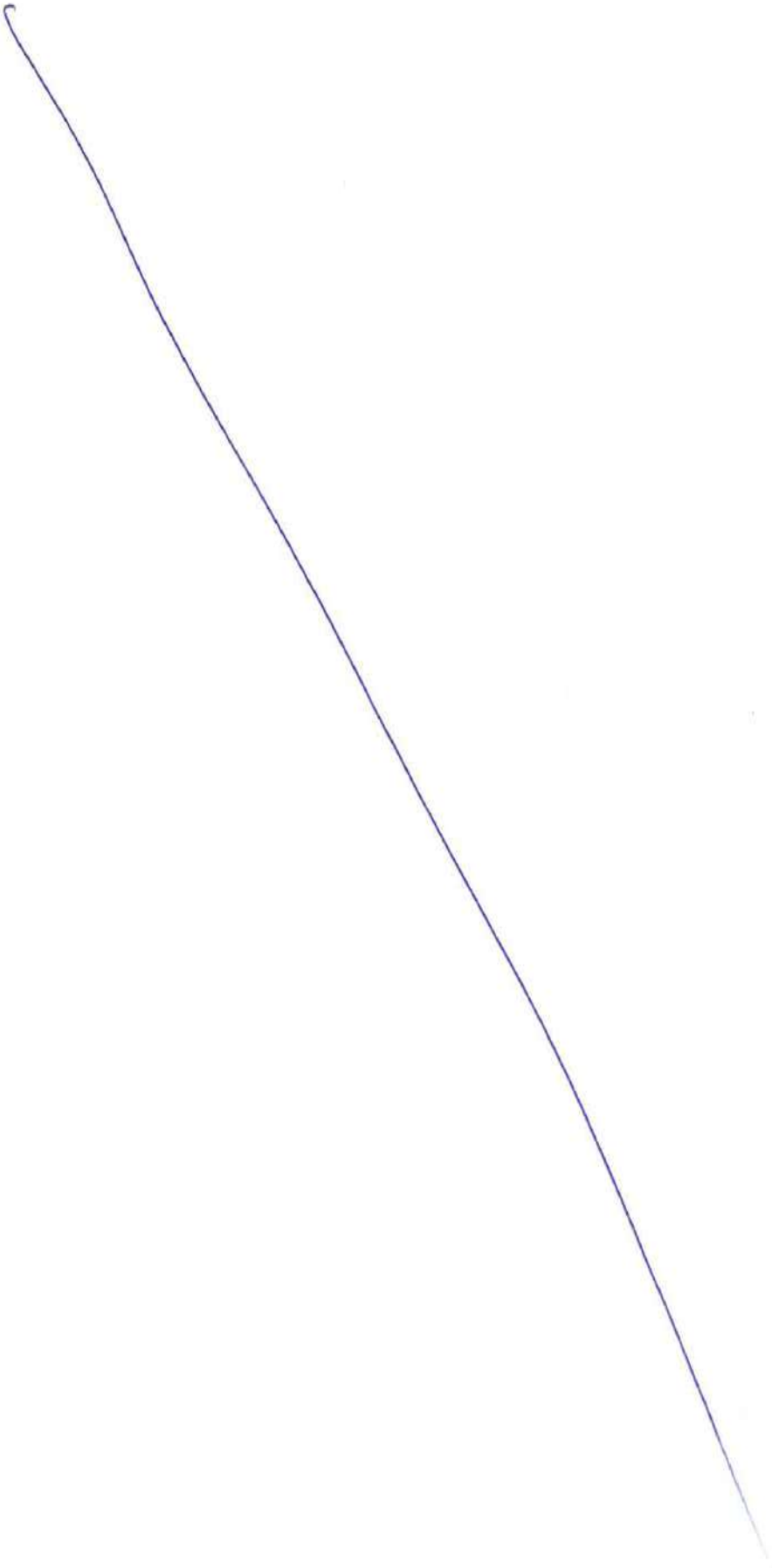


Quality Assurance Plan

BU:

Department:

Sl. No	Type of Record	Description	Minimum retention period
1	Project Initiation Documents	(PIDs) and supporting documentation	Ten years after completion of project
2	Feasibility study reports	reports	ten years after issue
		draft reports	two years after date of last paper
		Working papers	two years after date of last paper
		Correspondence	five years after date of last paper
3	Contract operation and monitoring	Records of complaints	Ten Years
		Disputes over payment	Ten Years
		Final accounts	Ten Years
		Minutes and papers of meetings	Ten Years
4	Contractors	approved nominations	one year after issue
		rejected nominations	one year after issue
		approved list	when new list is issued
		removals/ suspensions	Five years after the end of the project
5	Financial documents	-	Five years after completion of project
6	Project meetings	-minutes -correspondence	five years after date of last paper five years after



			date of last paper
7	Reports (such as quality reviews, highlight reports, GANTT charts)	interim final evaluation draft	five years after issue at the end of the project
8	Project Quality reports	Inspection reports, Qualification reports, Handovering records & Mockup reports	Five years

Instruction for preparation of Method Statements

1) **OBJECTIVE:** Ensure uniformity in all procedures and to ensure that the procedures meet the design, customer, statutory bodies and organization's intent for doing a particular work.

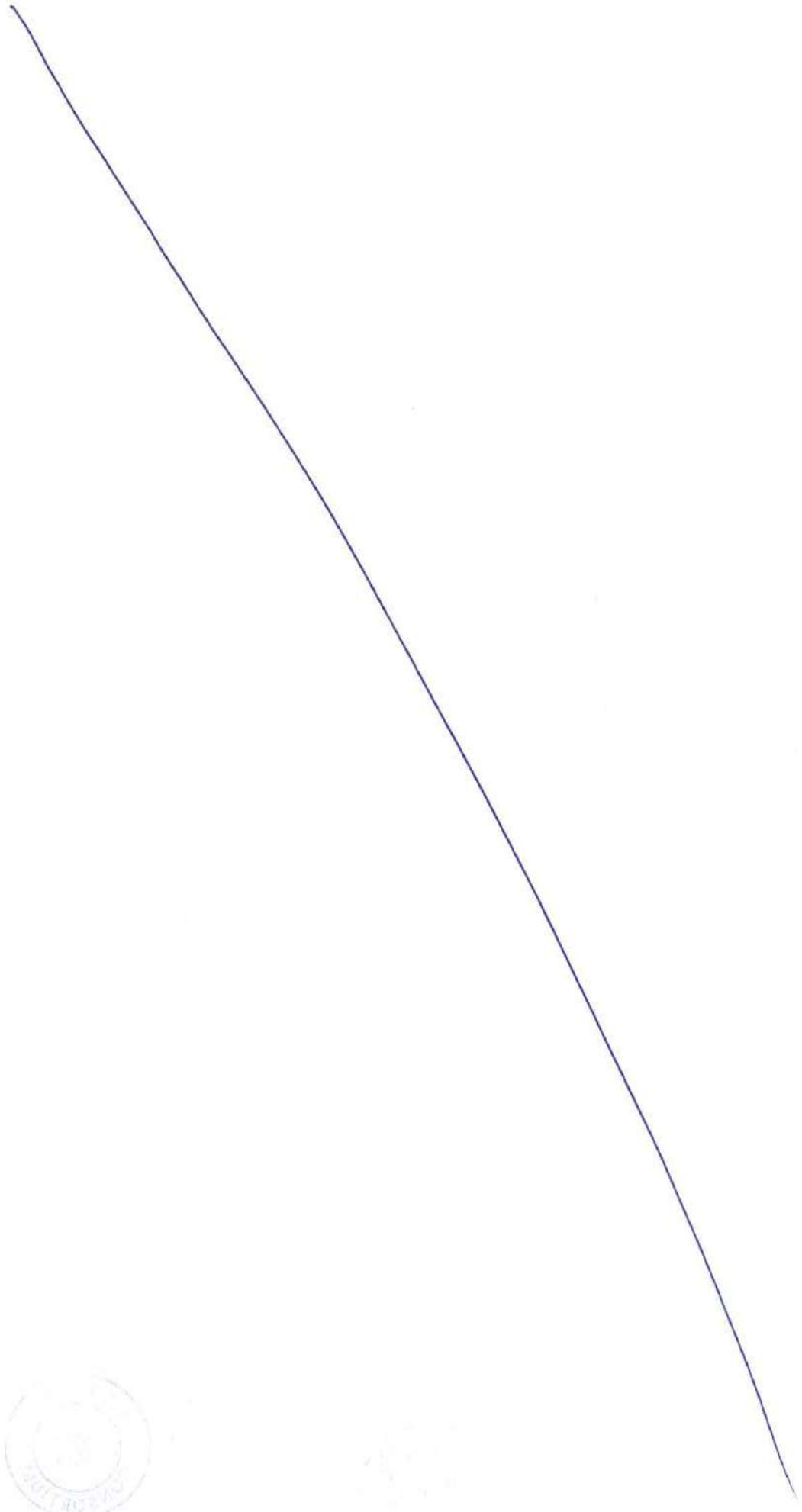
2) **SCOPE:** All construction activities at Site.

3) **PROCEDURE:**

The Site Construction Procedures henceforth referred to, as Method Statement shall consist of the following:

a) Title & Site Approval Page **(Model 1)**
b) Client approval Page if required by Client in same model as below
c) Revision Record Sheet **(Model 2)**
d) Guidelines for writing Method Statement **(Model 3).**

The Method Statements should be prepared by the site prioritising the sequence of works and submit to client (if approval required) by going for trial mock-ups (required for some jobs) before proceeding on with the actual work at the site.
Wherever client specifies the format for writing method statements the same shall be followed.



Quality Assurance Plan

Model: 1

TITLE: ***METHOD STATEMENT FOR CONSTRUCTION OF FLEXIBLE PAVEMENT***

PROCEDURE NO : ***WP / RW / FP / 1***

WORK ORDER NO : ***W 0001 / 53***

Rev. No			
Date:	DD/MM/YYYY		
	Prepared by (Section Engg)	Reviwed By (QMC Site)	Approved by (Project in-charge)

Model: 2

REVISION RECORD

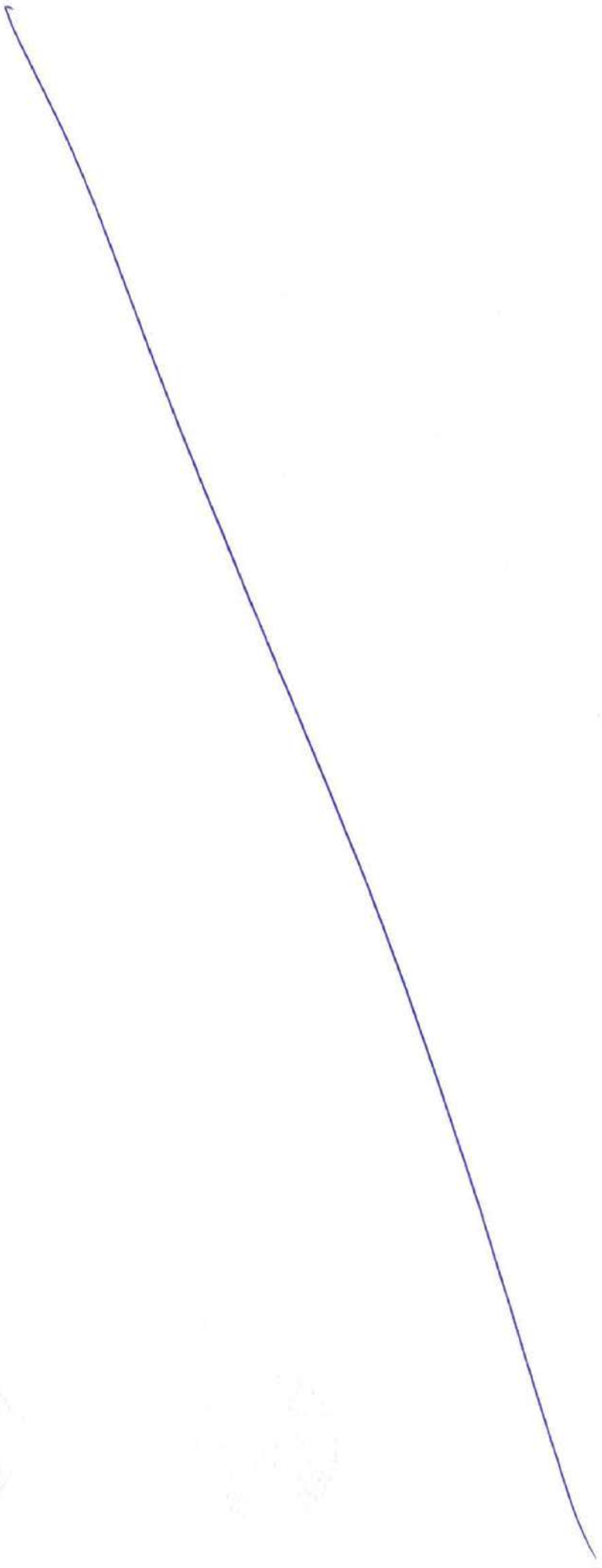
Rev.No	Date of revision	Page No	Details of revision	Prepared by	Reviewed by	Approved by
0	-	-	INITIAL ISSUE	-	-	-

Model: 3

Guidelines for writing site procedures

1. TITLE: A title which is descriptive of the item or activity to which the procedure or the instruction applies, and which includes identification No. or date and an approval status.

2. PURPOSE: General purpose of the procedure should be written here.



Quality Assurance Plan

3. APPLICABILITY / AREA OF APPLICATION: A clear statement of the areas to which the procedure or the instruction is applicable.

4. REFERENCES: References such as applicable codes and specifications, drawing nos. etc.

5. RESPONSIBILITY: Please mention "Responsibility of implementation of this procedure lies with _____:.

6. DESCRIPTION (Sequential actions): Step by step instructions in the degree of detail necessary for performing a required function or task and the records required. This can also include description of Equipment's. Accessories & Calibration requirements.

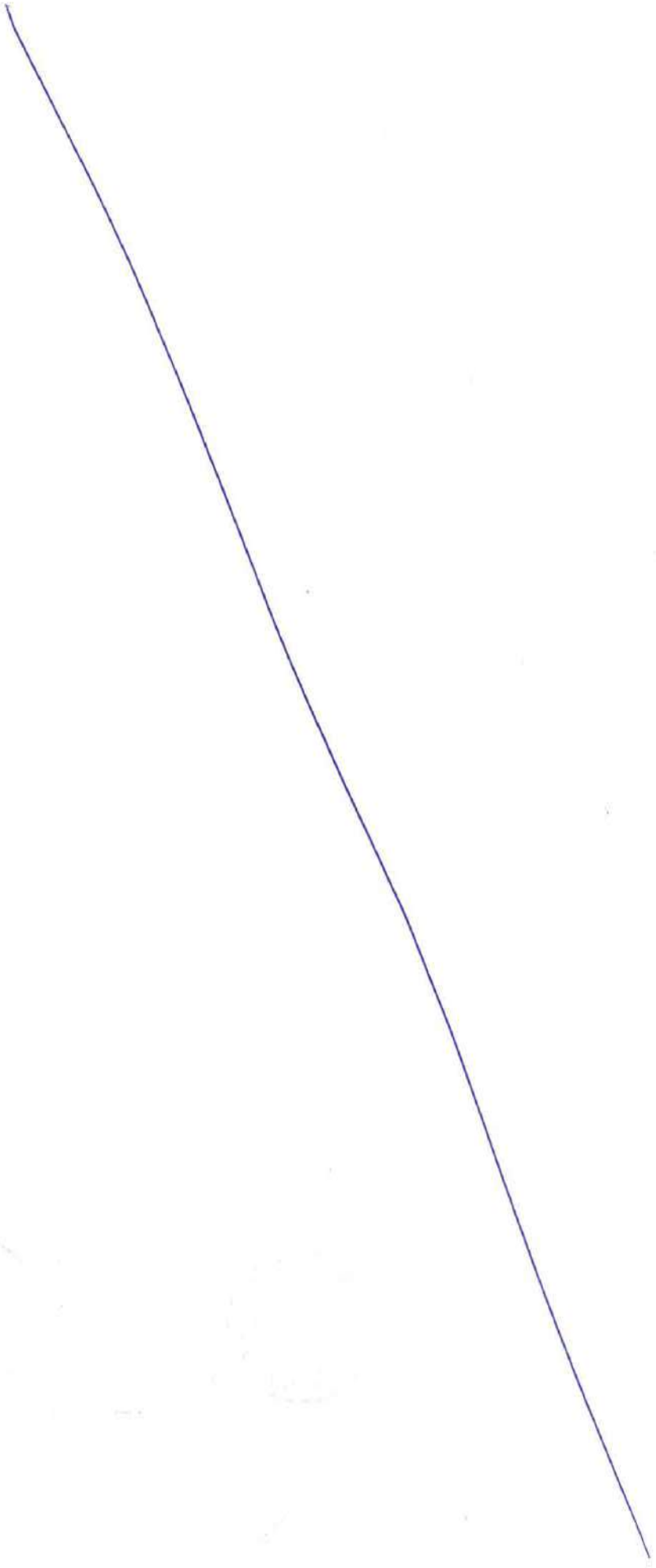
7. ACCEPTANCE CRITERIA: Appropriate quantitative or qualitative acceptance criteria for determining that activities have been satisfactorily completed.

8. CHECK LIST: For complex procedures checklist may be included as a part of the procedure or may be appended.

9. PRECAUTIONS / SAFETY: Precautions to alert the individual performing a task to those measures necessary to protect equipment and personnel during installation, inspection and test.(Job Safety Analysis-JSA)

10. RECORDS: All necessary data should be recorded in a suitable format. Format should contain the column for review and acceptance by Competent Authority.

11. ANNEXURES: Sketches, drawings and product catalogues to be annexed wherever required.



Quality Assurance Plan

Guidelines for Sub-Contractors Performance

1) **OBJECTIVE:** To establish, implement and maintain the system for Performance of Sub-Contractors engaged in project sites.

2) **SCOPE** : Sub-contractors deployed in areas.

3) **GUIDELINES:**

- Rating of sub-contractors category wise.
- Labour supply contractor.
- Piece rate contractor.
- Contractor with LMP(Labour, materials and equipment)
- Contractor for P&M maintenance
- Contractor for Hiring out Equipment
- Contractor for transport materials, P&M and Personnel

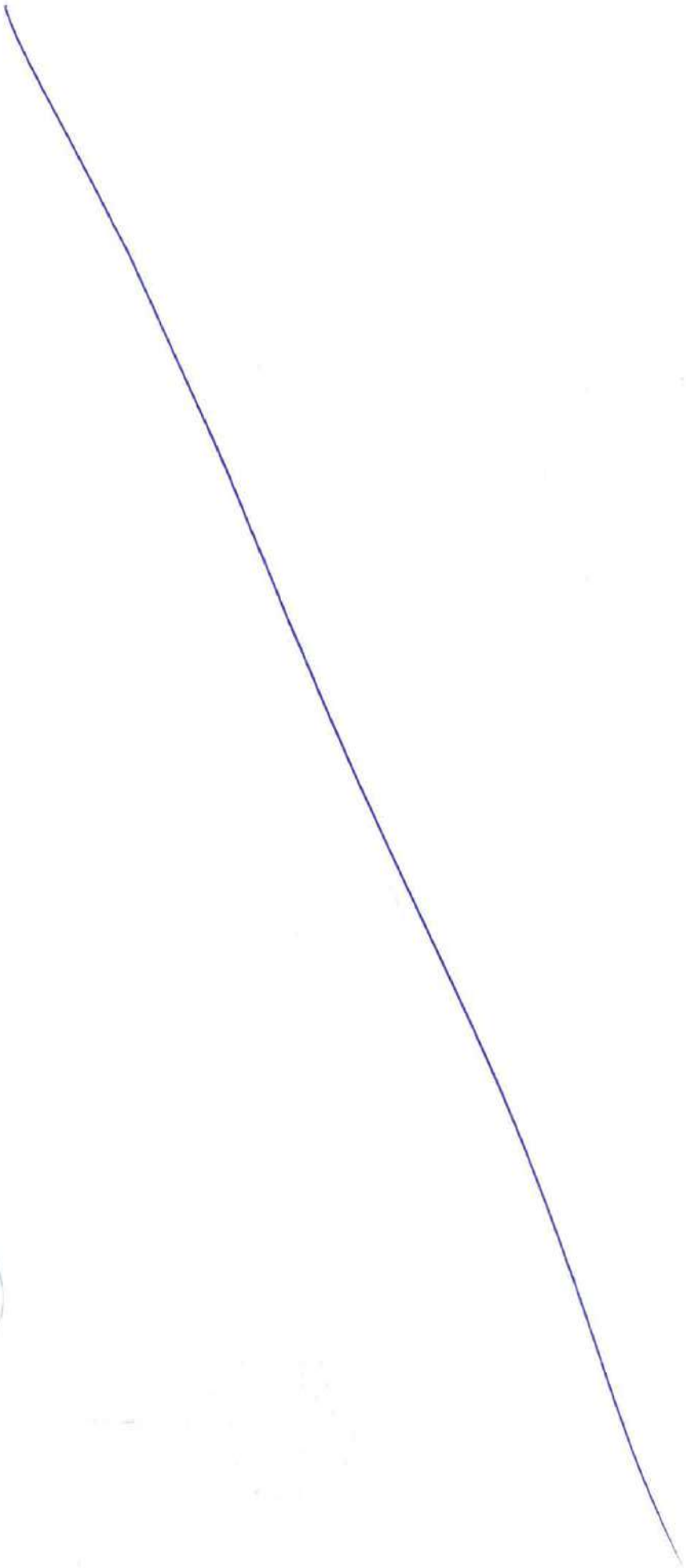
4) PROCEDURE:

Performance of subcontractor shall be categorized as below.

Category "A"	: Very Good	(90%-100%)
Category "B"	: Good	(70% - 89%)
Category "C"	: Average	(60% - 69%)
Category "D"	: Poor	(< 60%)

Consider the following Areas for the purpose of performance evaluation of subcontractors and evaluate at the frequency set in work procedure.

- **Safety Record:**
  - PPEs compliance. ,
  - House Keeping
  - Workmen discipline
  - Attitude towards safety.
  - Actions on instructions with target date and time.



Quality Assurance Plan

- **Ability to Mobilize at short Notice** :
  - Mobilization of Labour,
  - Mobilization of materials and
  - Mobilization of equipment.

- **Labour Productivity:**
  - Reporting time
  - closing time
  - Repetition of works
  - Meeting productivity norms.

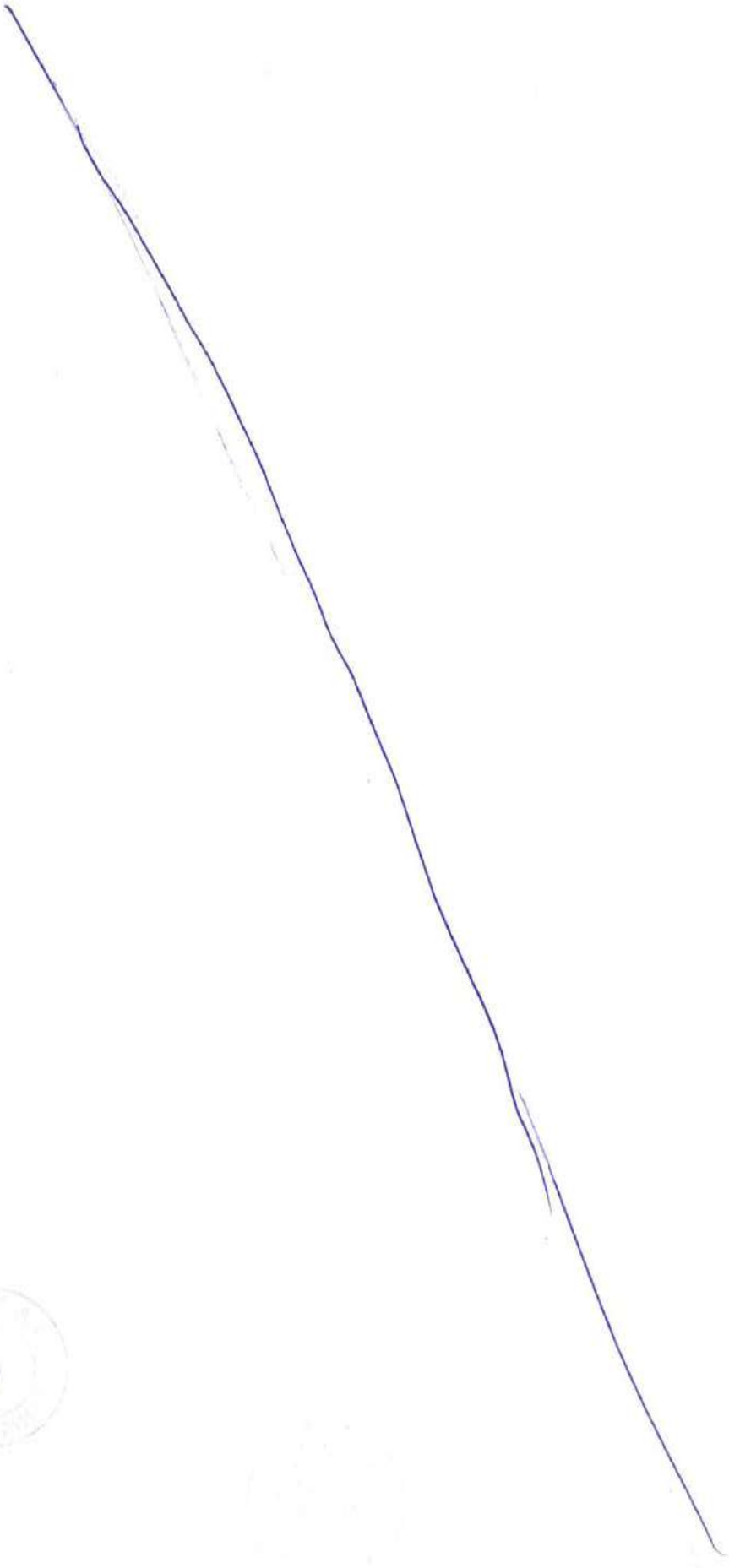
- **Control over wastage:**
  - Storage of material,
  - Accountability of issued materials
  - Effective utilization without wastage
  - Ownership for materials.

- **Control over workmen:**
  - Conflict or un reasonable behavior
  - Child labour

- **Judicious & effective utilization of client material:**
  - Log book on material receipt
  - Daily reconciliation of material
  - Unauthorized utilization of materials
  - Right material for the right job

- **Co-operation with other agencies:**
  - Any conflict or unreasonable behavior with other contractors.
  - Unwanted discussions with other contractors.
  - Untruth complaints

- **Compliance to labour regulations :**
  - working hours
  - Over time
  - Rest time at work
  - Frequent dismissal of labour



The actions on rating shall be as below.

Rating		Action
Very Good	(90% - 100%)	• No action required.
Good	(70% - 89%)	• Inform verbally about their rating and motivate to enhance rating percentage in future
Average	(60% - 69%)	• Warning letter shall be issued informing them about their rating and motivating to enhance rating percentage in future
Poor	< 60%	• Shall be disqualified on consecutive rating.

Note: In case of disqualification, necessary remedial measures and LD recovery , if applicable as per WO terms, shall be implemented.

5) RELATED DOCUMENTS:

- SCM 01 WP 01 – Procedure for Procurement Resources from HQ.

6) RELATED DATA:

- SCM 01WP01 – Procedure for Review and Monitoring of Performance

7) RELATED RECORDS:

- Sub-contractor performance Report Form – PQP WP 10 F 01

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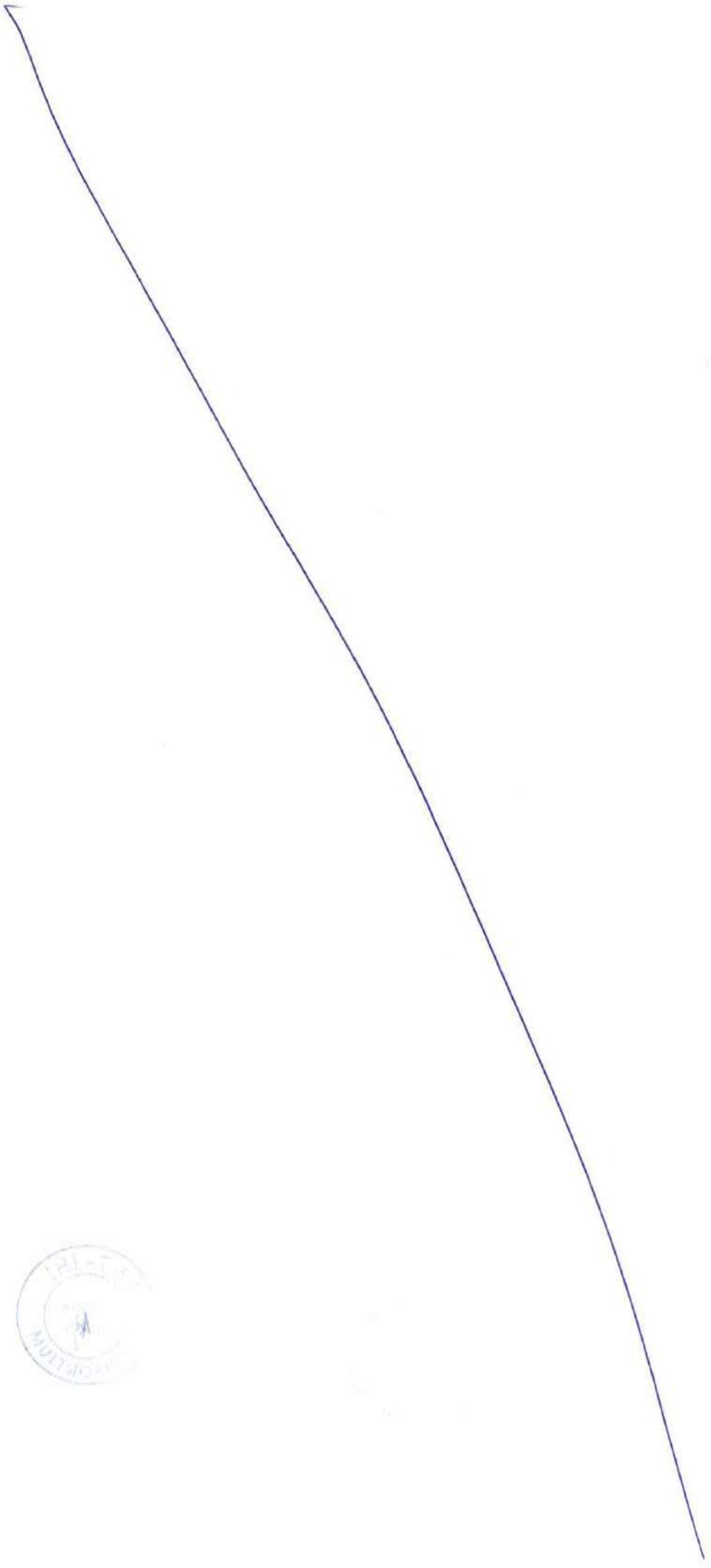
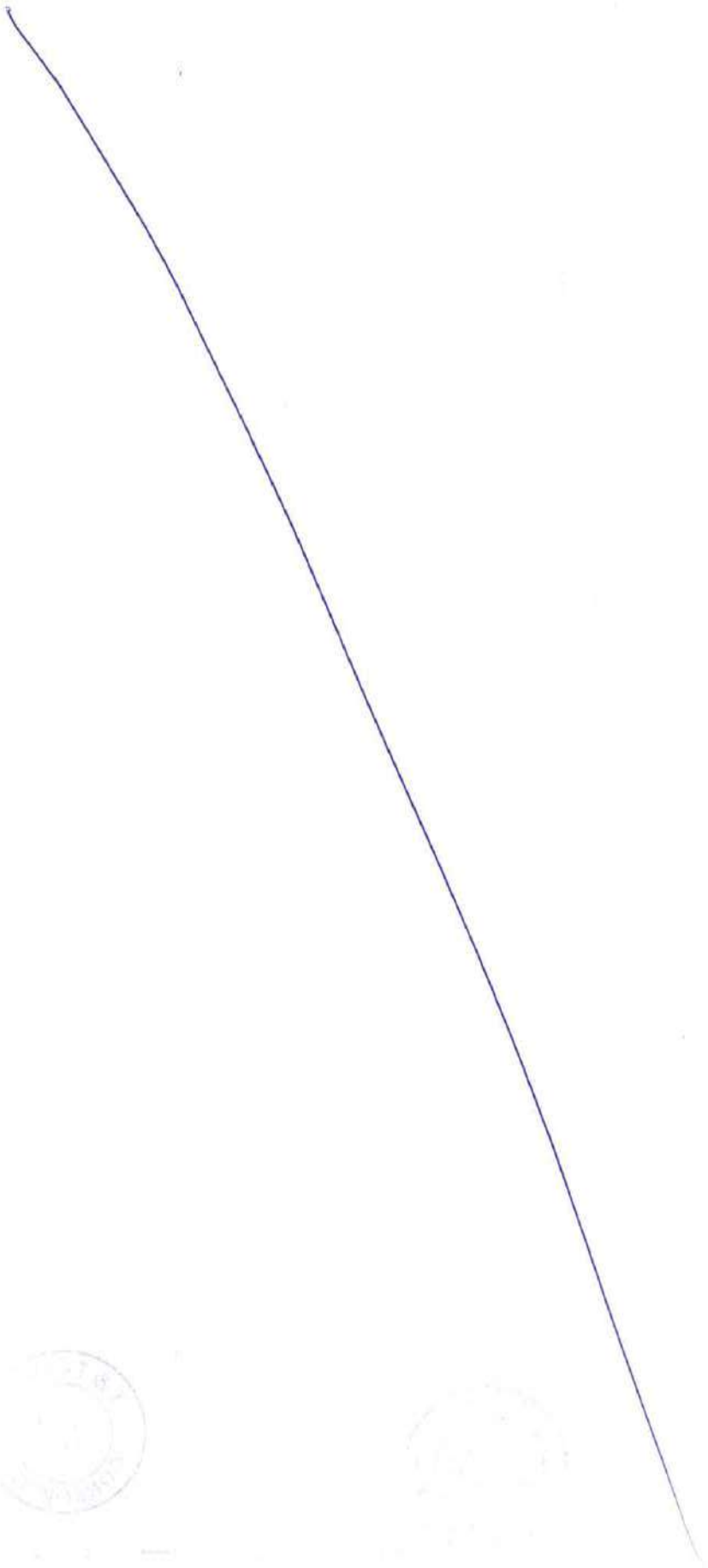


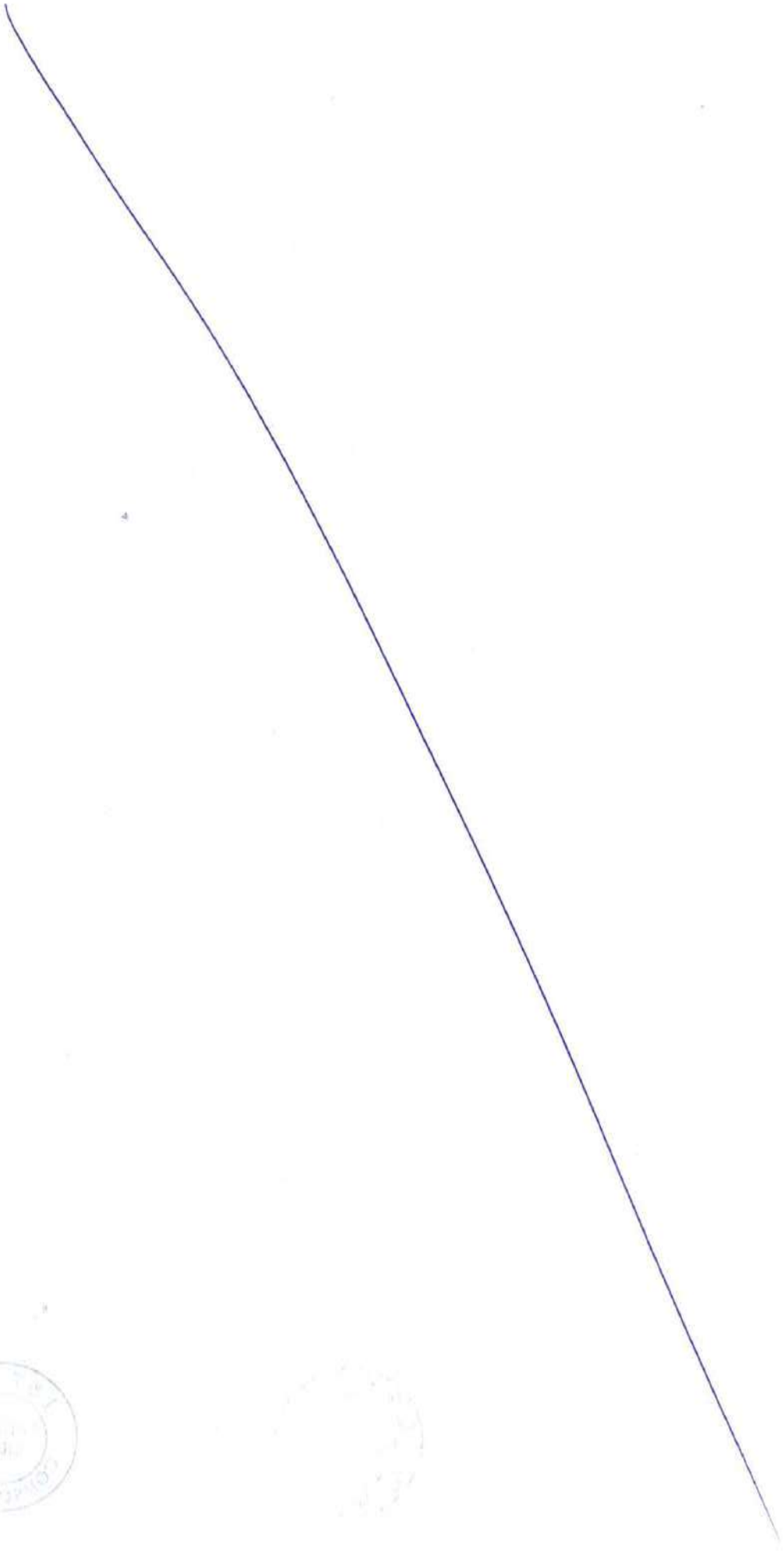
FORMATS



Quality Assurance Plan

List of Formats

Sl.No:	Reference No:	Description
1	PQP /WP 01 F 01	Quality objectives for the year (Plan & Review)
2	PQP/ WP 02 F 02	Master list of controlled copy holders
3	PQP/ WP 02 F 03	List of Codes/Standards
4	PQP/WP 03 F 01	List of Records
5	PQP/WP 05 F 01	Minutes of Management Review Meeting
6	PQP/WP 09 F 01	Monthly Quality Report
7	PQP/WP 13 F 01	Performance report of sub-contractor
8	PQP/WP 14 F 01	List of Instruments for calibration
9	PQP/WP 15 F 01	Customer complaints register
10	PQP/WP 16 F 01	Audit Plan
11	PQP/ WP 16 F 02	Audit summary report
12	GEN 10 F 03	Non – conformance report
13	PQP/ WP 17 F 01	Inspection Test Plan
14	PQP/ WP 08 F 01	Statutory Compliance Check List
15	PQP 4.3 F 01	Scope of QMS
16	PQP MS F 01	List of Identified Method Statements
17	PQP ITP's F 01	List of Identified ITP's



Quality Assurance Plan

QUALITY OBJECTIVES (PLAN / REVIEW) FOR THE YEAR .....

Project :
Business Unit :
Department / Function :

Sl. No	Objectives	Sub Objectives	Measures	Target Value	Action Plan*	Review Frequency	Review Report Reference

Date :

Prepared By :

Approved By (HOD/ PI) :

*Action plan details are applicable only for at planning stage.
* May be maintained as separate document.

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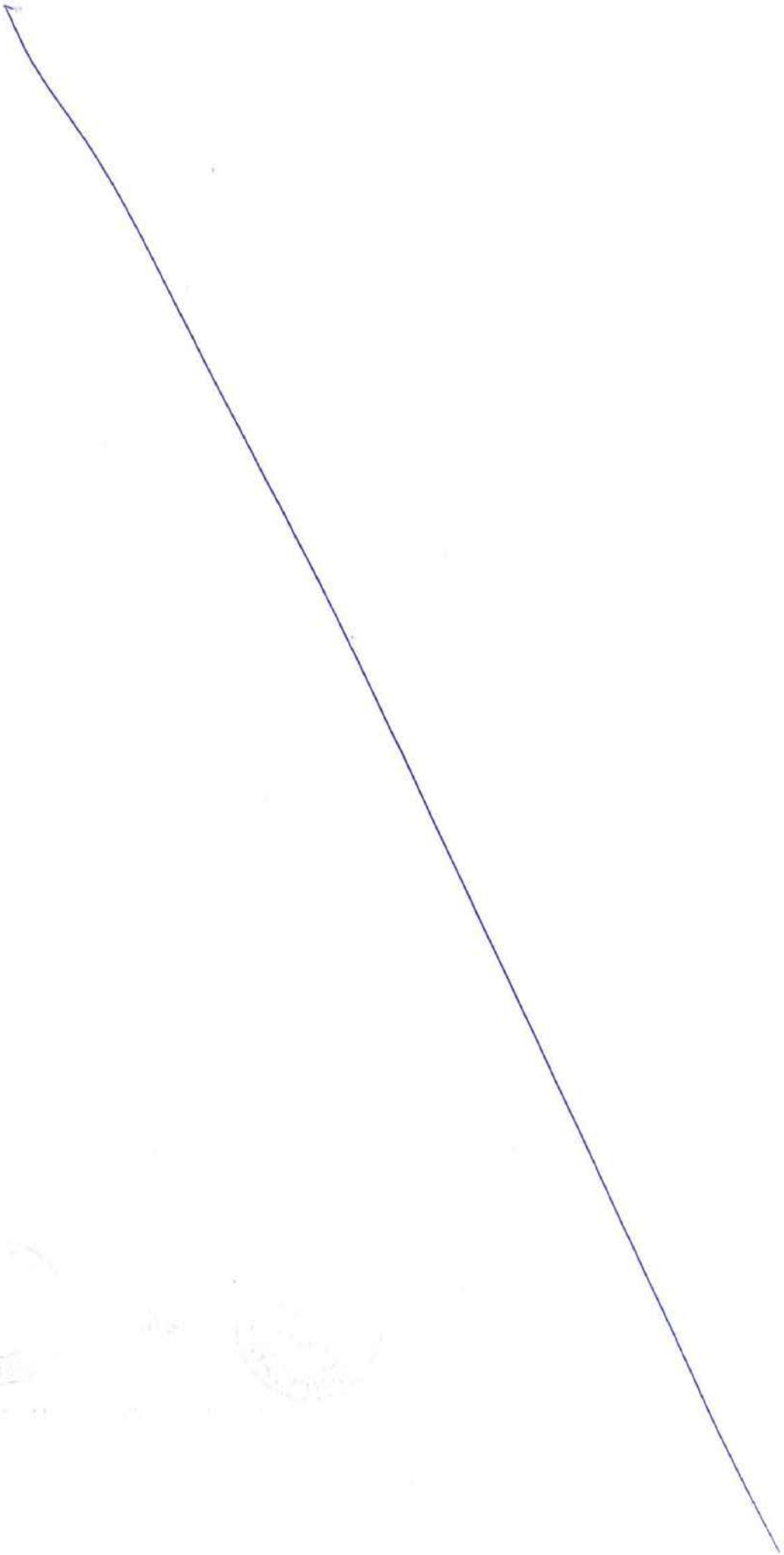


Quality Assurance Plan

MASTERLIST OF CONTROLLED COPYHOLDERS

Sl No	Controlled copy no	Date of Issue	Documents	Name of Copy holder	Revision
1	**Project Quality Plan : Owner of Master copy – MR Site**				
			Complete PQP	PM	
			As per procedure responsibility matrix	Customer (As applicable)	
			-- Do --	Planning Engineer	
			-- Do --	Quality Incharge	
			-- Do --	In charge – Sections	
			-- Do --	P&M In charge	
			-- Do --	Accounts & Administration In charge	
			-- Do --	Site safety co-ordinator	
			Complete PQP	QM at HQ	

This shall be available along with master copy. When changes are made and approved, MR (site) shall issue revisions and issue revised copy to applicable controlled copy holders.

Work procedures / method statements shall be separately issued and controlled.

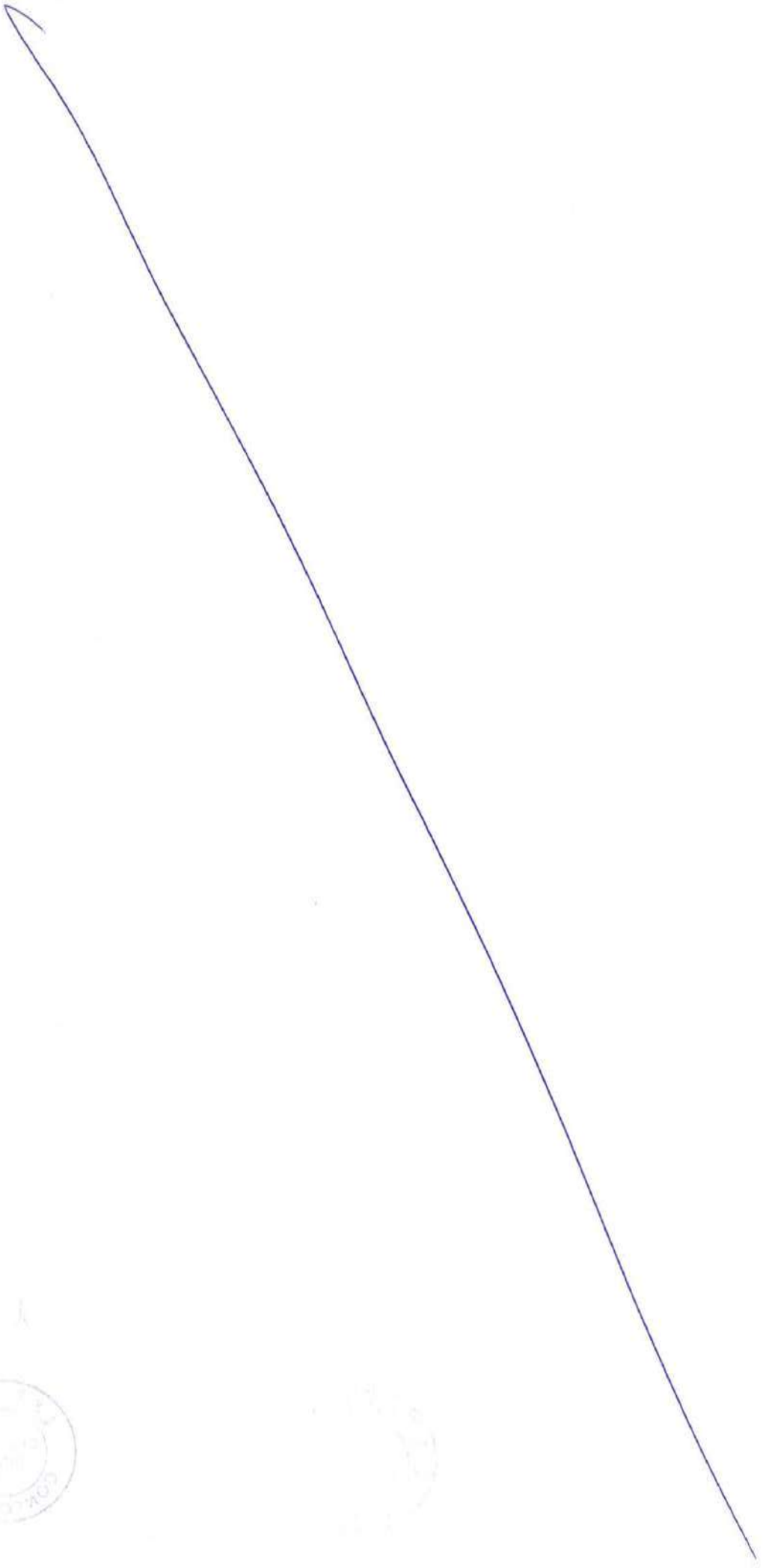
MR (Site)

Name:

Signature:

Date:

Note: Withdrawal evidence of superseded documents to be established as per procedure.



Quality Assurance Plan

LIST OF CODES / STANDARDS

Sl. No.	Date of Receipt	Code / Standard	Year of Revision / edition	Contents	Place of Keeping

Date:

Revision No:

Prepared by:

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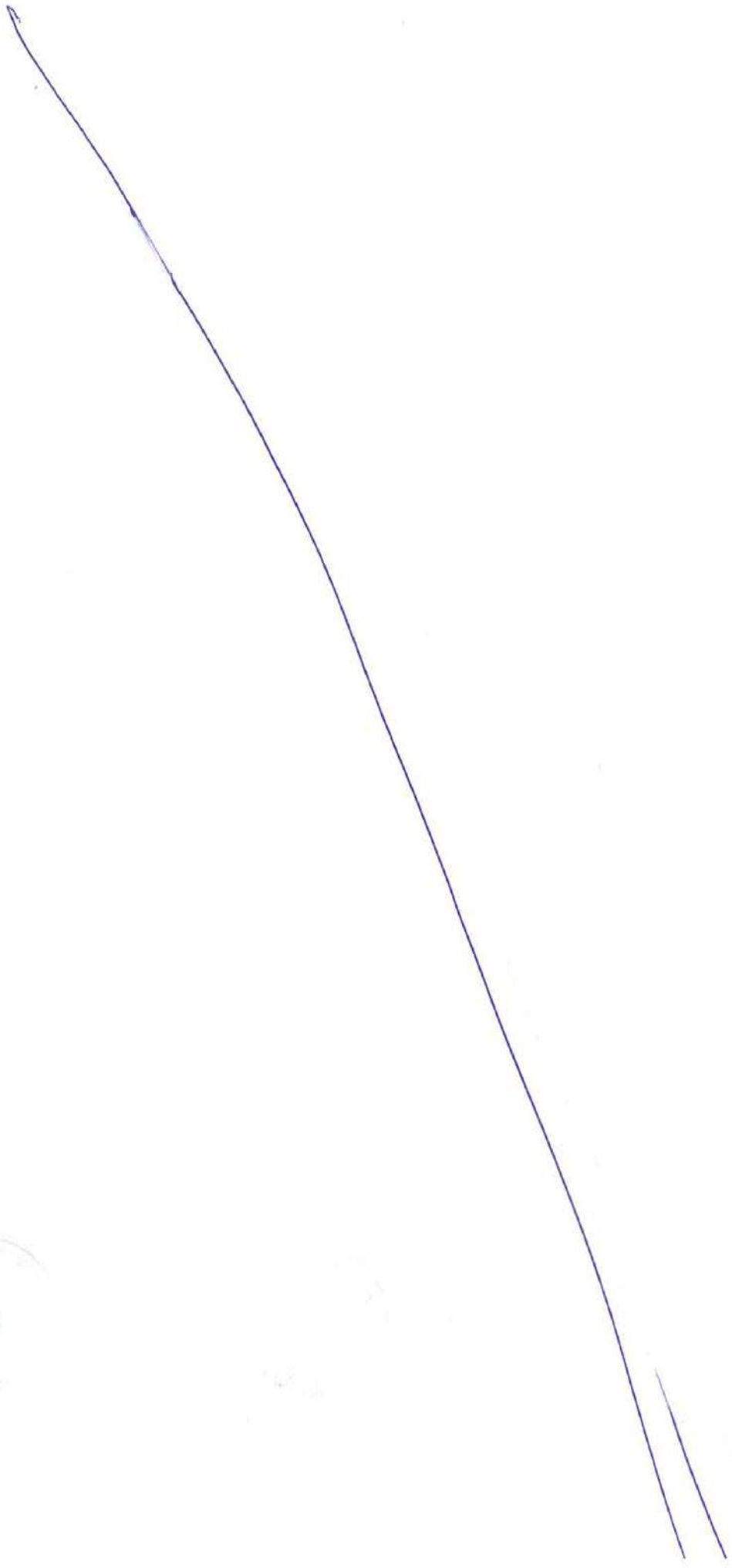
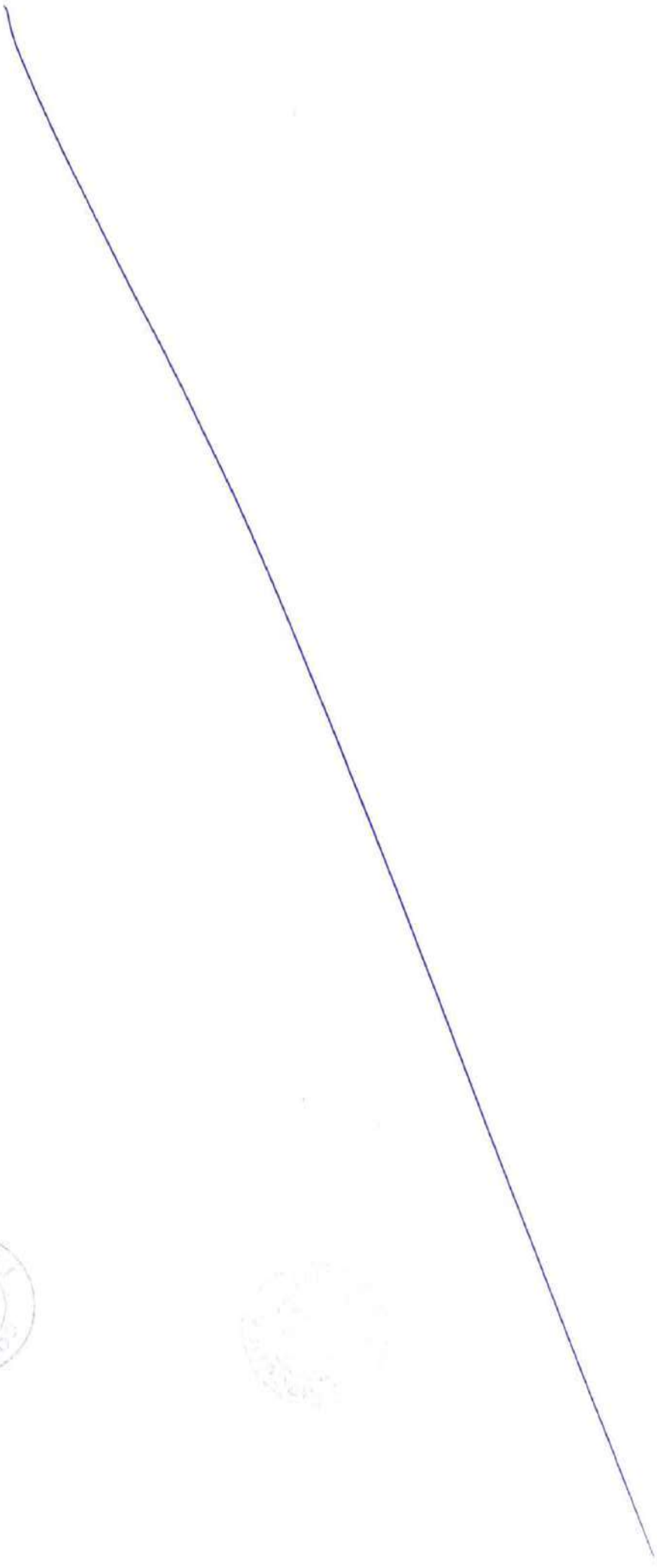


LIST OF RECORDS

Department:

Sl No	Record description	Records (tick as applicable)		Hard copy			Retention period	Electronic Media			
		Hard Copy	Elect copy	File No/ title	Indexing	Location		File name	Back up		
									Method*	Location	Frequency of updatation

* If records are maintained electronically identify method of back up (Hard disk at different location or CD / DVD or any storage device).



MINUTES OF MANAGEMENT REVIEW MEETING

Date……. MOM No……..

Participants Name Department Designation

1.
2.
3.
4.
5.

Sl. No.	Agenda	Discussions	Decision	Action by Person	Date

Convenor:

NAME:
SIGNATURE:
DATE ISSUED:

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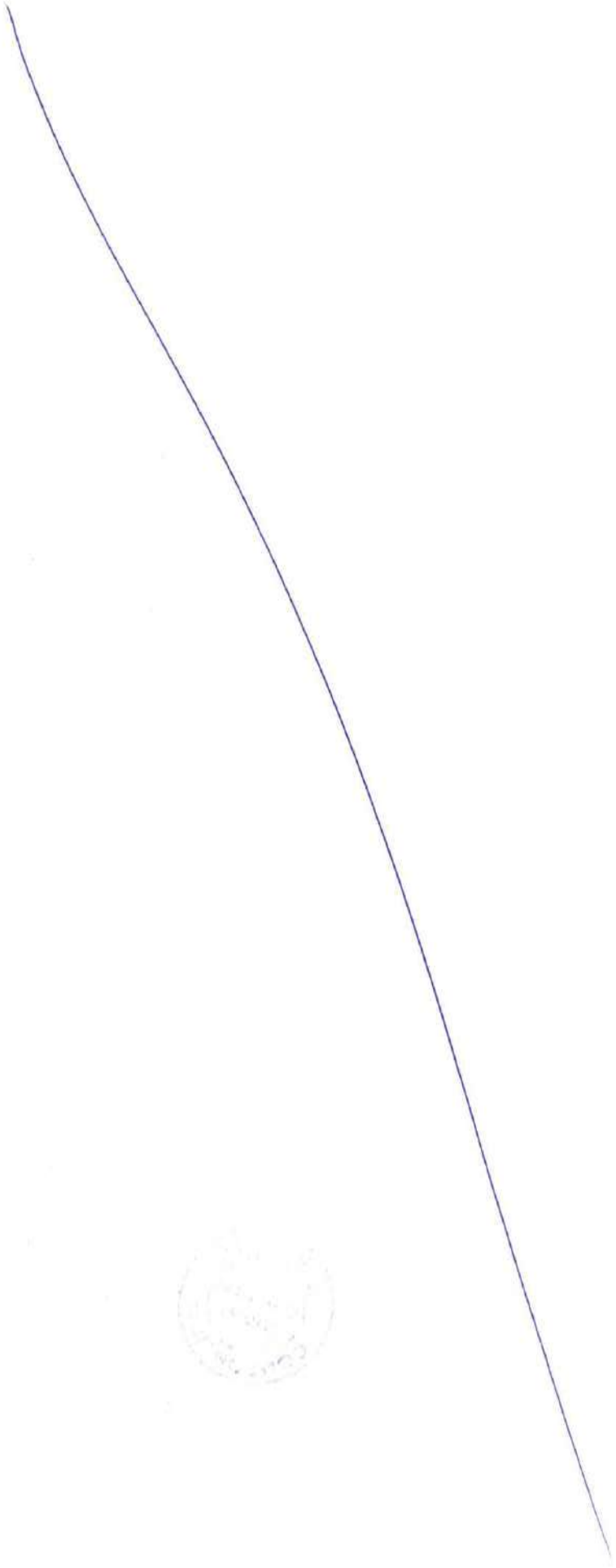


Quality Assurance Plan

Monthly Quality Report for the month of .....

Project Name:

Date :

1. Change in Quality Team (Including contract staff & Trainees)*

Sr. No	Name	P.S. No.	Designation	Roles & Responsibility	Email id	Mobile Number
1.						
2.						
3.						

*- Only new joinee /transferred staff /resigned staff details to be provided

a) No of staff available till last month -
b) No of staff newly joined/transferred from other sites -
c) No of staff resigned/transferred to other sites -
d) Effective number of staff as on date -

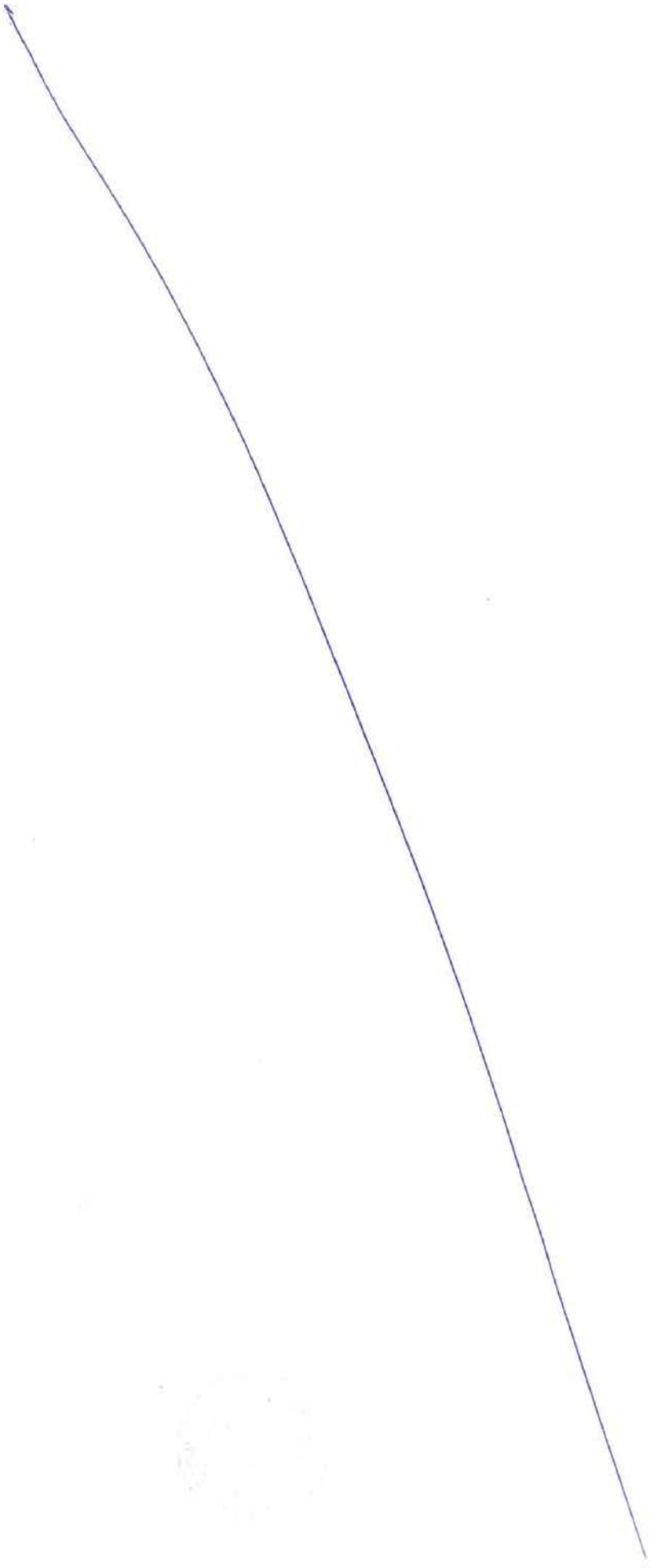
2. Work Methodologies/Work procedures & ITPs (Established during this month only).

Sr. No.	Work Procedure & ITPs	Approval Status by client
1.		
2.		
3.		
4.		

a) Cumulative No of Work procedures/Method statements as on date -
b) Cumulative No of QAP/ITPs established as on date -

3. No of internal auditors (ISO 9001: 2015) available as on date -

4. (A) Customer NCRs / complaints (Pertaining to quality
   - NCRs/ complaints in this month –



- NCR / complaints cumulative –

List of **OPEN** NCR/Complaints:

Sr. No	Description	Date of Issue	Related to (Design/Material/ Workmanship or any)	Target Date for Closure

(B) List of **OPEN** NCR (Internal /HQ/LRQA- NCRs):

Sr. No	Description	Date of Issue	Related to (Design/Material/ Workmanship)	Target for Closure

5. Customer rating for Product quality: Annexure – 1

6. Project status up to this month :

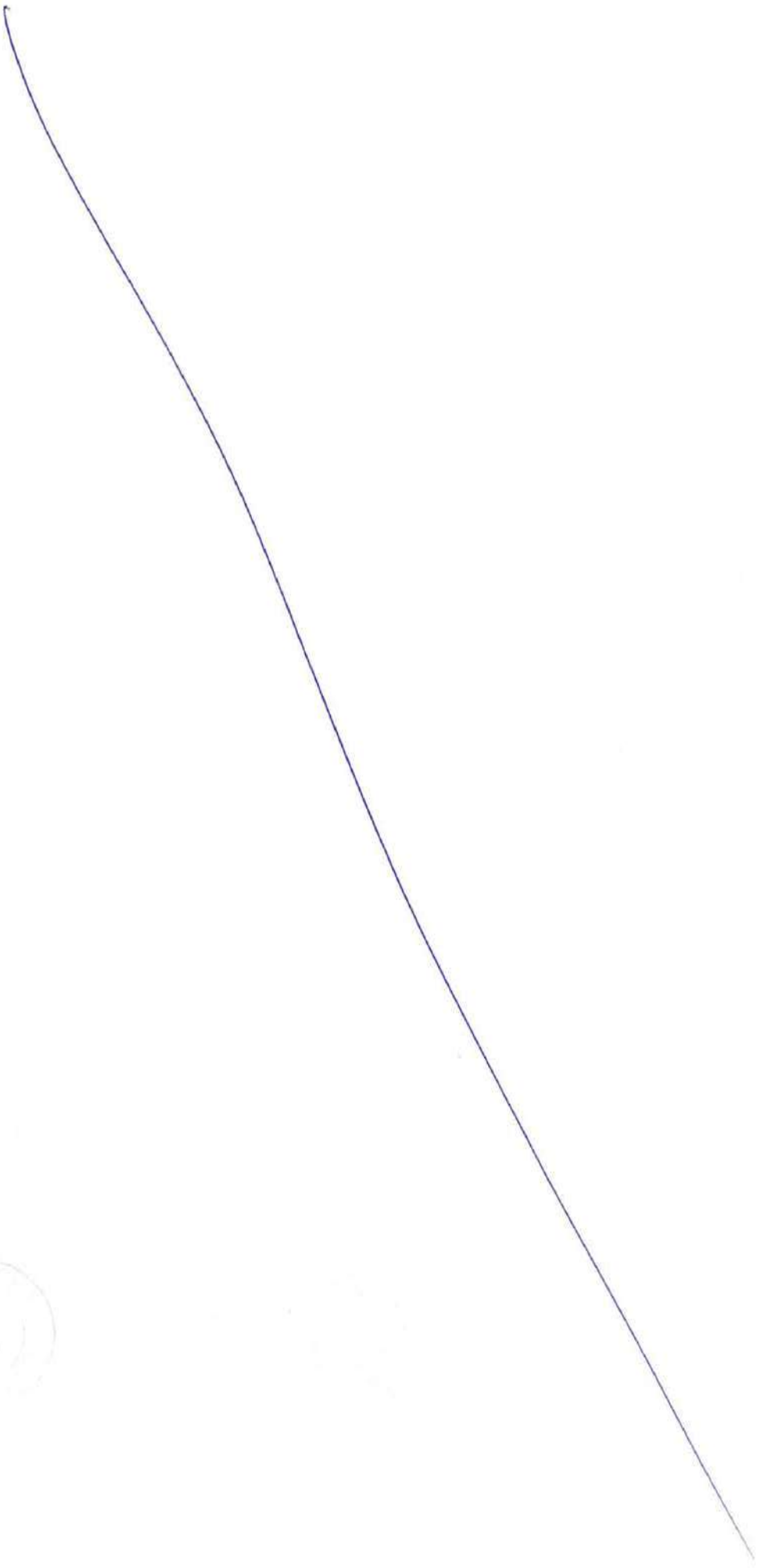
Status parameter	Date / Value
a. Date of commencement :	
b. Date of completion as per contract:	
c. Expected date of completion :	
d. Reasons if contract completion exceeds:	
e. Original contract value :	
f. Revised contract value:	
g. Percentage of physical completion :	

7. Best Practices/Improvements or Innovation (Preferably with photo evidence)

8. Support required if any:

L&T - IHI CHENNAI (INDIA) CONSORTIUM

MMRDA MUMBAI METROPOLITAN REGION DEVELOPMENT AUTHORITY



Quality Assurance Plan

Sub-contractor quarterly performance for Q1 / Q2 /Q3 / Q4 /Job completion

Job Description		Job Site	
Business Unit		Subcontractor Category	
Subcontractor Name			
Phone		Date of Review	
WO Number		WO Description	
WO Date		WO value	
WO Start Date		WO end date	
Actual start date		Virtual Completion date	
Want Quarterly Performance rating		Yes / No	

S. NO	Area of performance	A-Very good (90% -100%)	B-Good (70% -89%)	C-Average (60%-69%)	D-Poor (< 60%)
1	Safety Record	O	O	O	O
2	Ability to mobilize at short notice	O	O	O	O
3	Labour productivity	O	O	O	O
4	Control over wastage of materials	O	O	O	O
5	Control over workmen	O	O	O	O
6	Judicious & efficient utilization of Infra OC's resources	O	O	O	O
7	Co-operation with other agencies	O	O	O	O
8	Compliance to labour regulations	O	O	O	O
	Remarks:				

Assessed By:

Signature:

Date:

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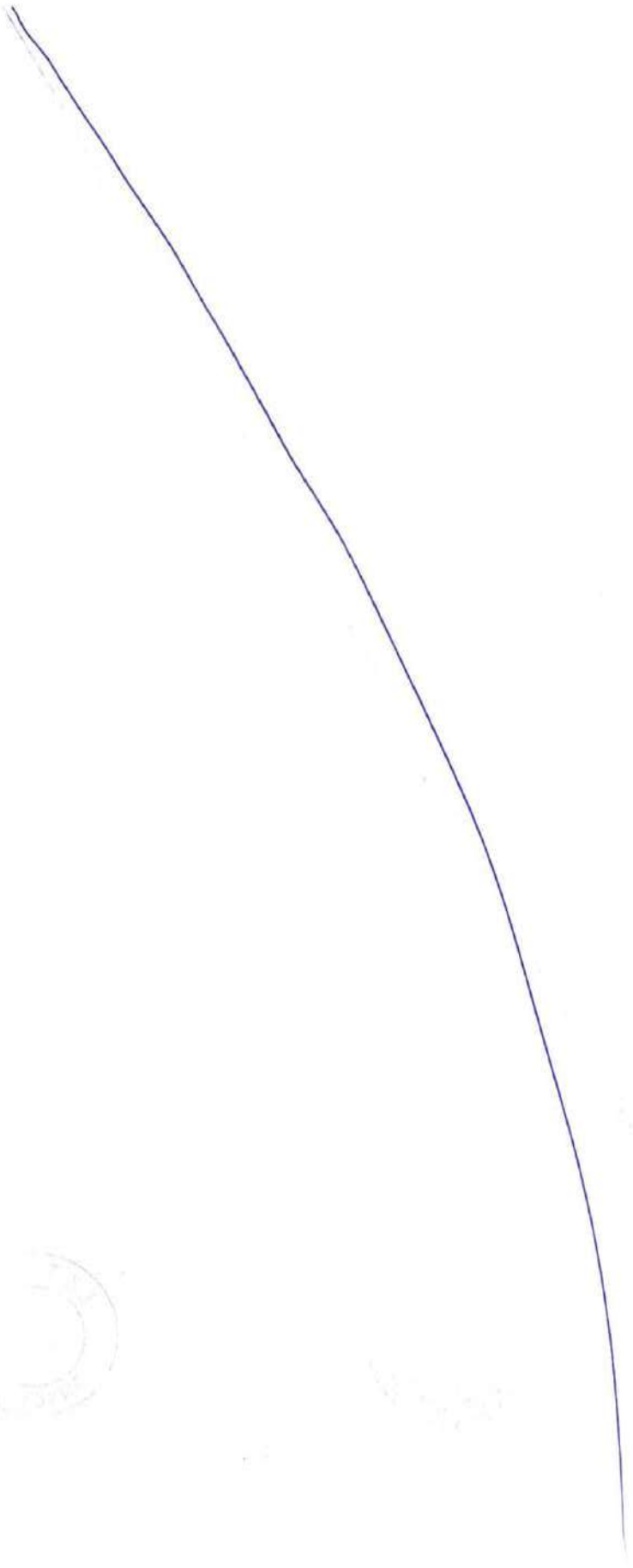

Quality Assurance Plan

LIST OF INSTRUMENTS FOR CALIBRATION

Sl. No.	Equipment. Description	Equipment Sl. No.	Internal / External Calibration	Frequency of Calibration	Least count / Accuracy	Date of Calibration	Due date of Calibration	Responsibility

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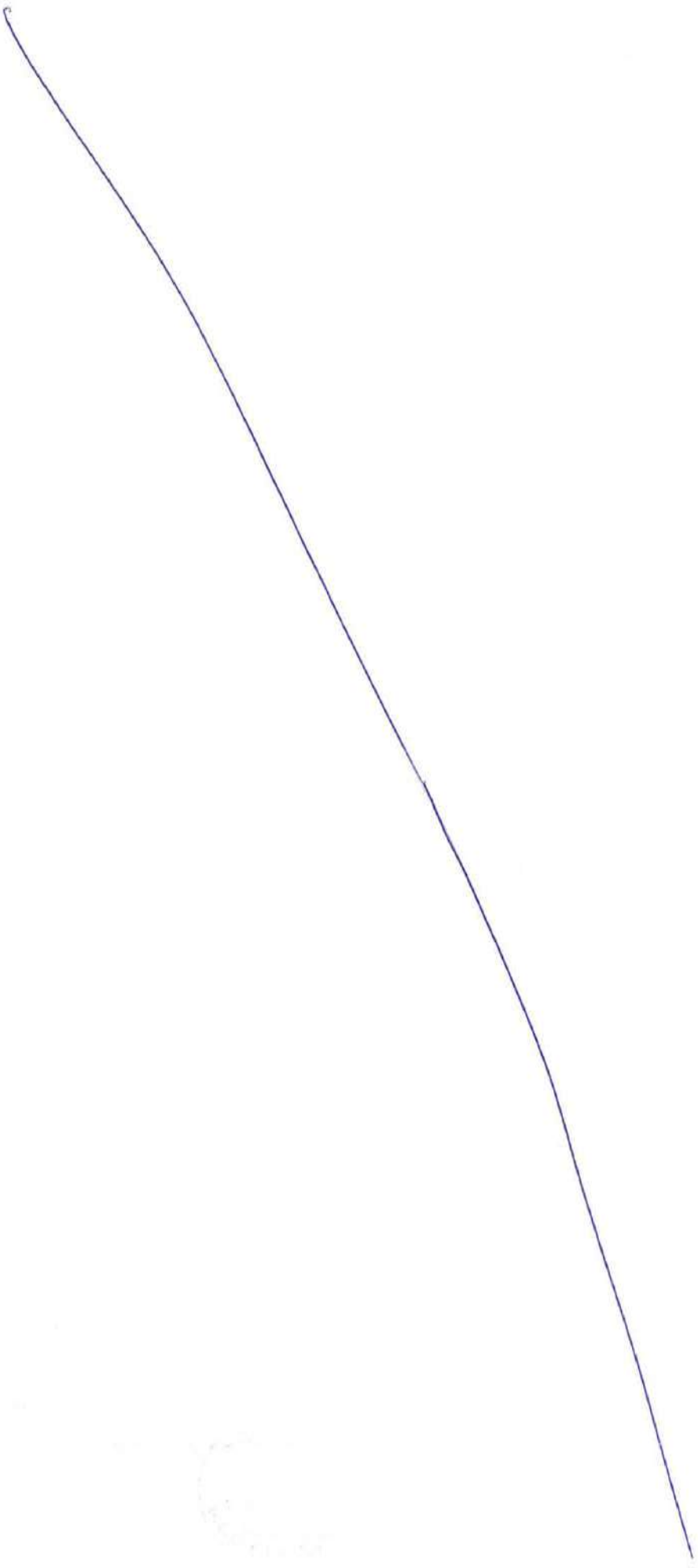
QA/QC In charge:

L&T - IHI CONSORTIUM CHENNAI (INDIA)

MMRDA MUMBAI METROPOLITAN REGION DEVELOPMENT AUTHORITY



CUSTOMER COMPLAINTS REGISTER

Project:

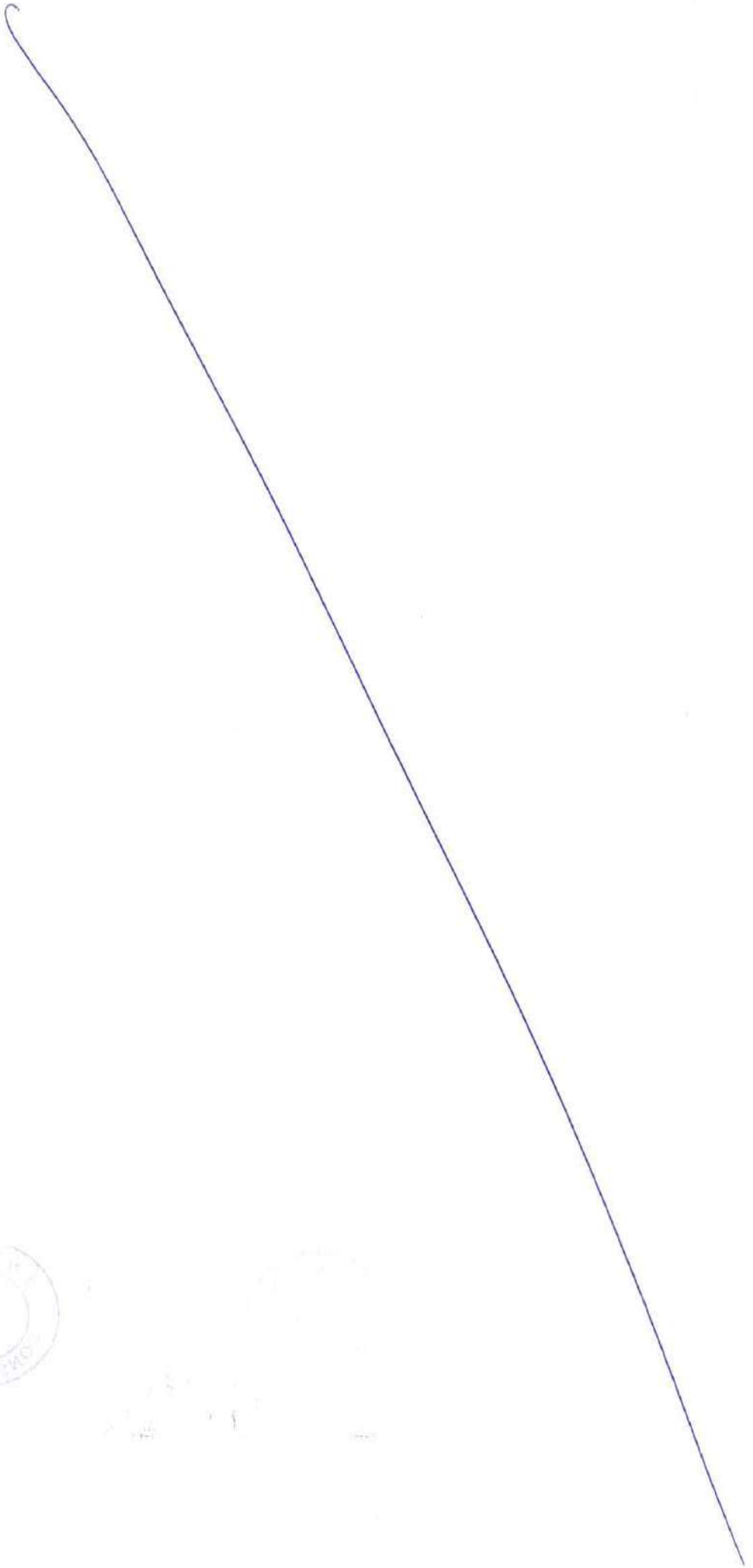
Complaint No.	Date of receipt	Nature of Complaint	Proposed Date of Closure	CA Taken	Atten dee	CA Completion date	Review action & Notification to Customer

REVIEWED BY

Project in charge

L&T - IHI CHENNAI (INDIA) CONSORTIUM

MMRDA MUMBAI METROPOLITAN REGION DEVELOPMENT AUTHORITY



L&T - IHI

Mumbai Trans Harbour Link Project (Package-1)

IFB No: MMRDA/ENG1/000752

Quality Assurance Plan

											AUDIT PLAN (YYYY-YY)																												PROJECT:																		
	Month		January				February				March					April					May				June					July					August					September					October					November					December			
Area to be Audited	Week No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	14	15	16	17	18	19	20	21	22	23	24	25	26	27	27	28	29	30	31	31	32	33	34	35	36	37	38	39	40	40	41	42	43	44	45	46	47	48	49	50	51	52	53
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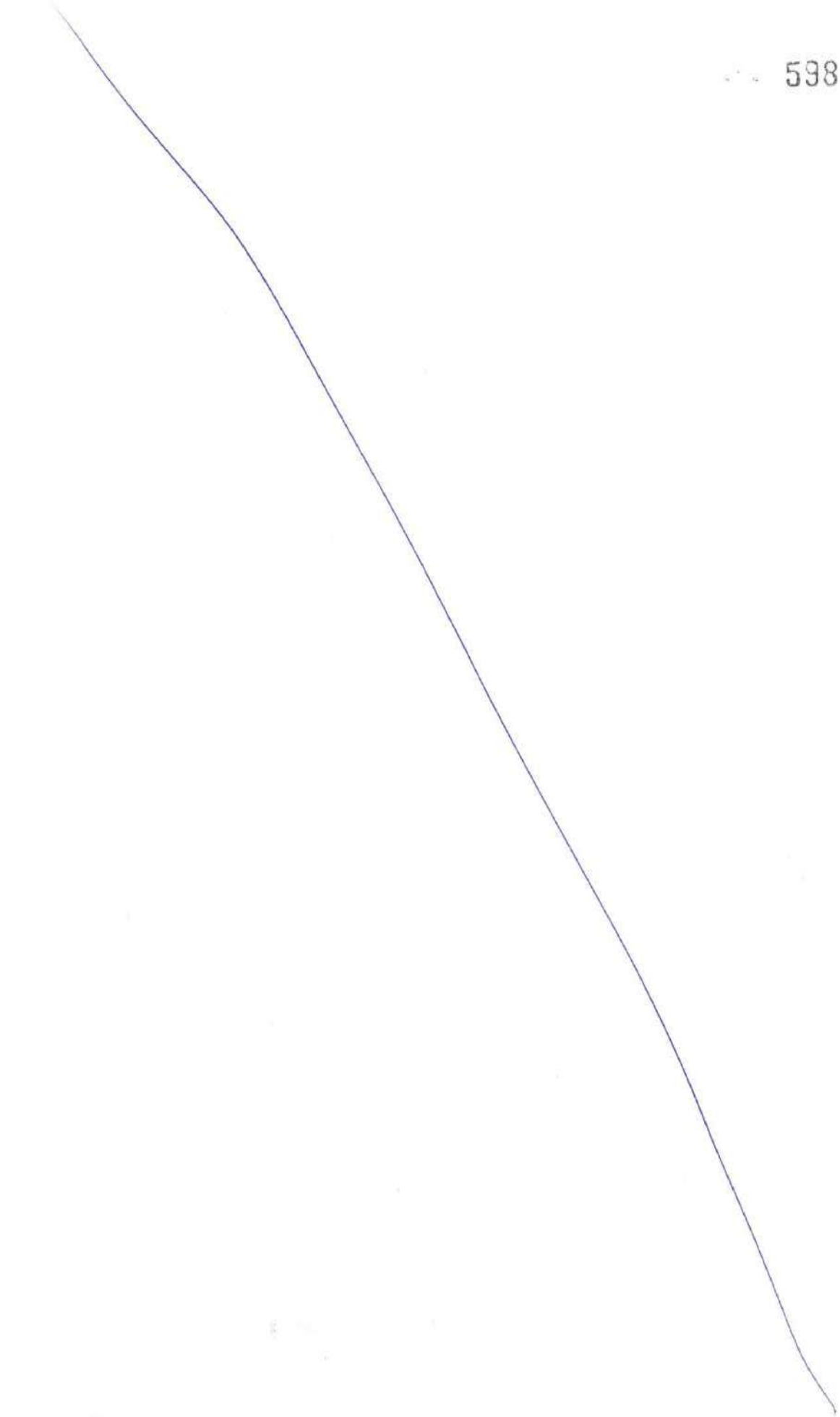
Legend:

Prepared by:		Signature:		Rev No.:	Plan			Extra Audit Performed	
Approved by:		Signature:		Date:	Actual			LRQA AUDIT performed	



Quality Assurance Plan

BU / Project :

AUDIT NO :

Audit Team :

DATE OF AUDIT :

Persons Contacted :

Audit highlights :

DETAILED AUDIT REPORT

S.NO	Area /Subject	Description of Observation	Remarks

Signature of Auditor

Note: If this is an electronic copy, signature is not required

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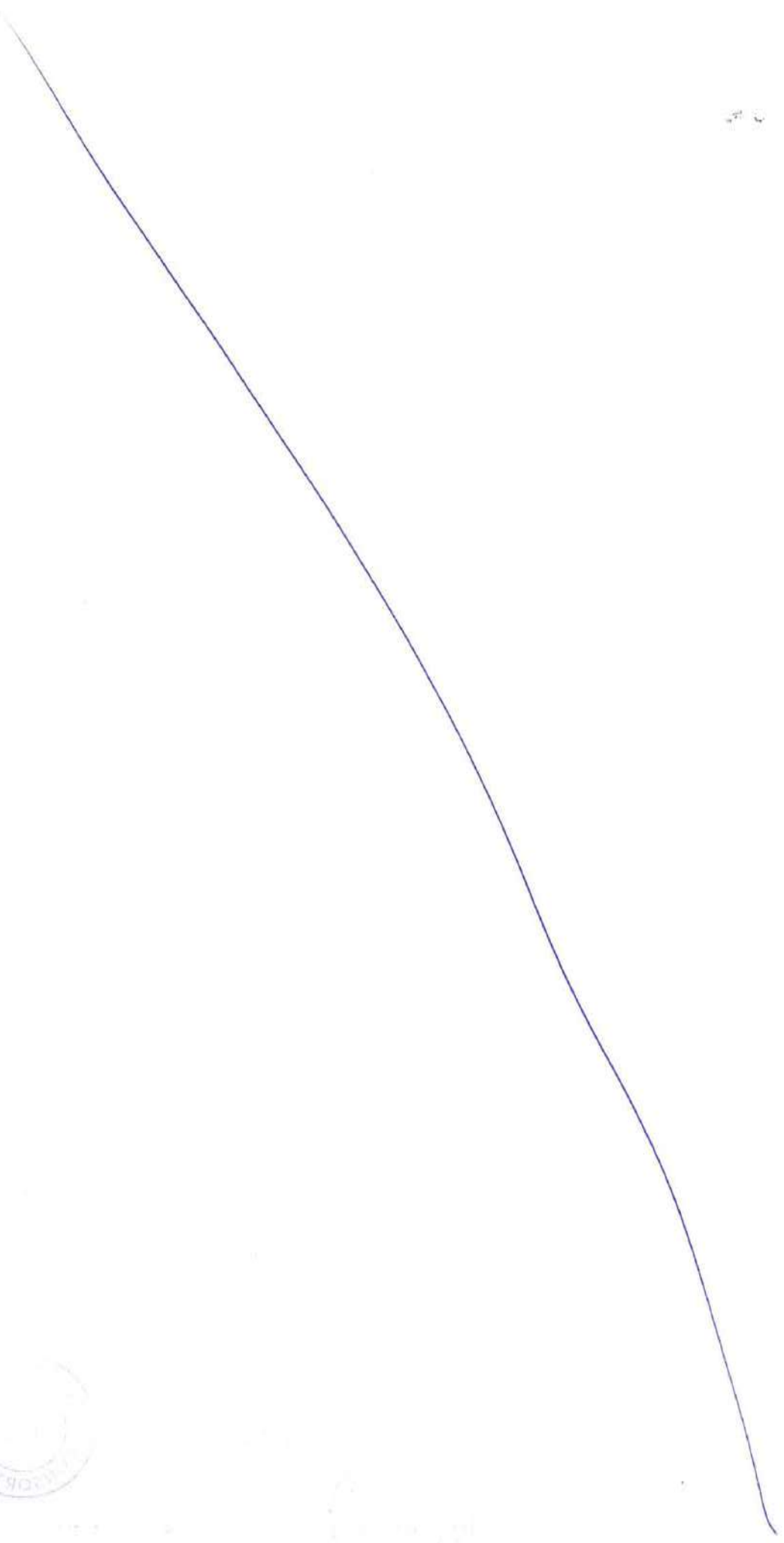
MMRDA MUMBAI METROPOLITAN REGION DEVELOPMENT AUTHORITY

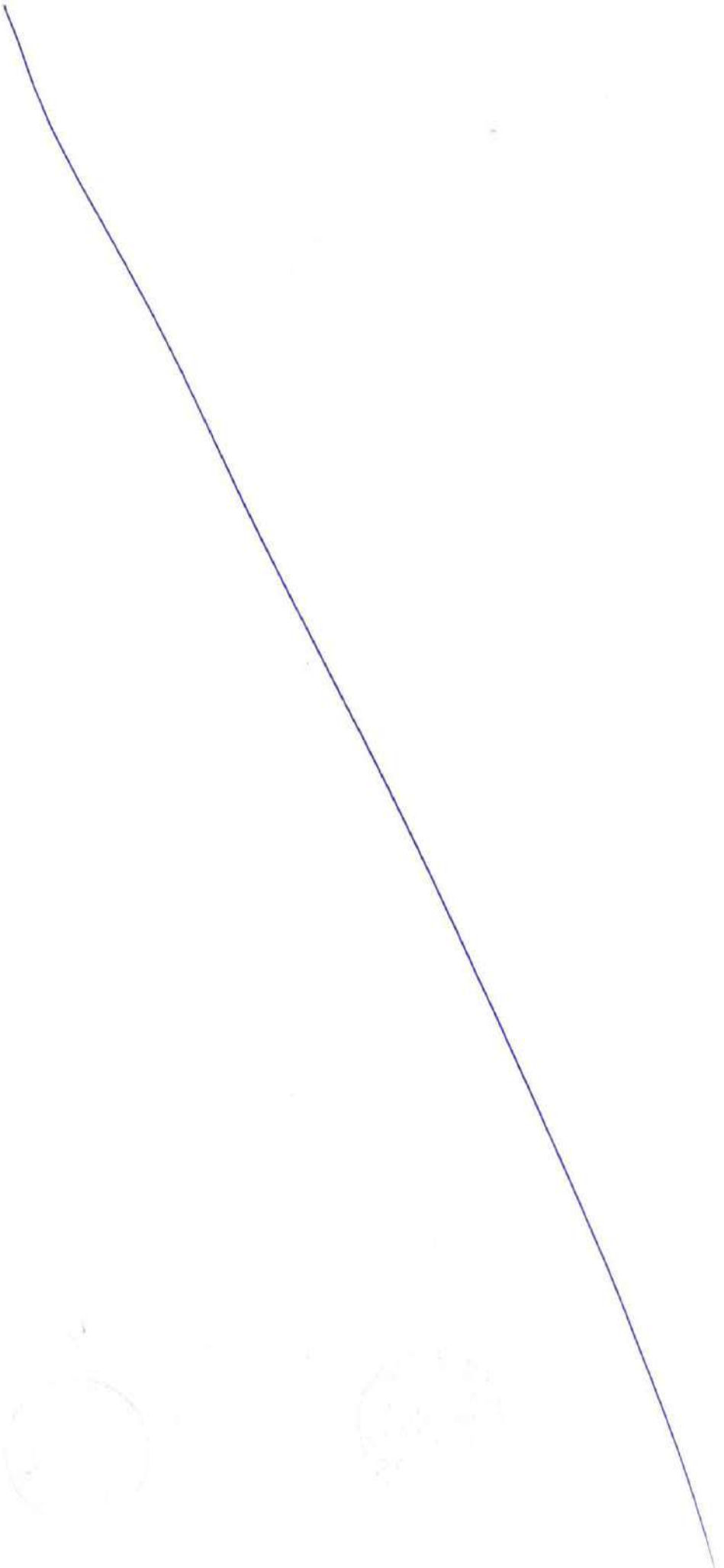


Quality Assurance Plan

Location:			Date:
Department:			Audit No.:
Auditor(s) :	Signature:		NCR No.:
Audited Document/Work:			
Non-conformance Observed:			
Objective Evidence of Non Conformance:			
Auditee Name: Signature: Date:	**NCR Categories** (tick one)		**ISO 9001 Reference: Clause(s)**
	MAJOR	**MINOR**	
Root causes of NC:			
Correction Proposed:			
Corrective Action Proposed : Signature of Auditee:			Completion target date:

MMRDA
MUMBAI METROPOLITAN REGION DEVELOPMENT AUTHORITY

L&T - IHI CHENNAI (INDIA) CONSORTIUM



Quality Assurance Plan

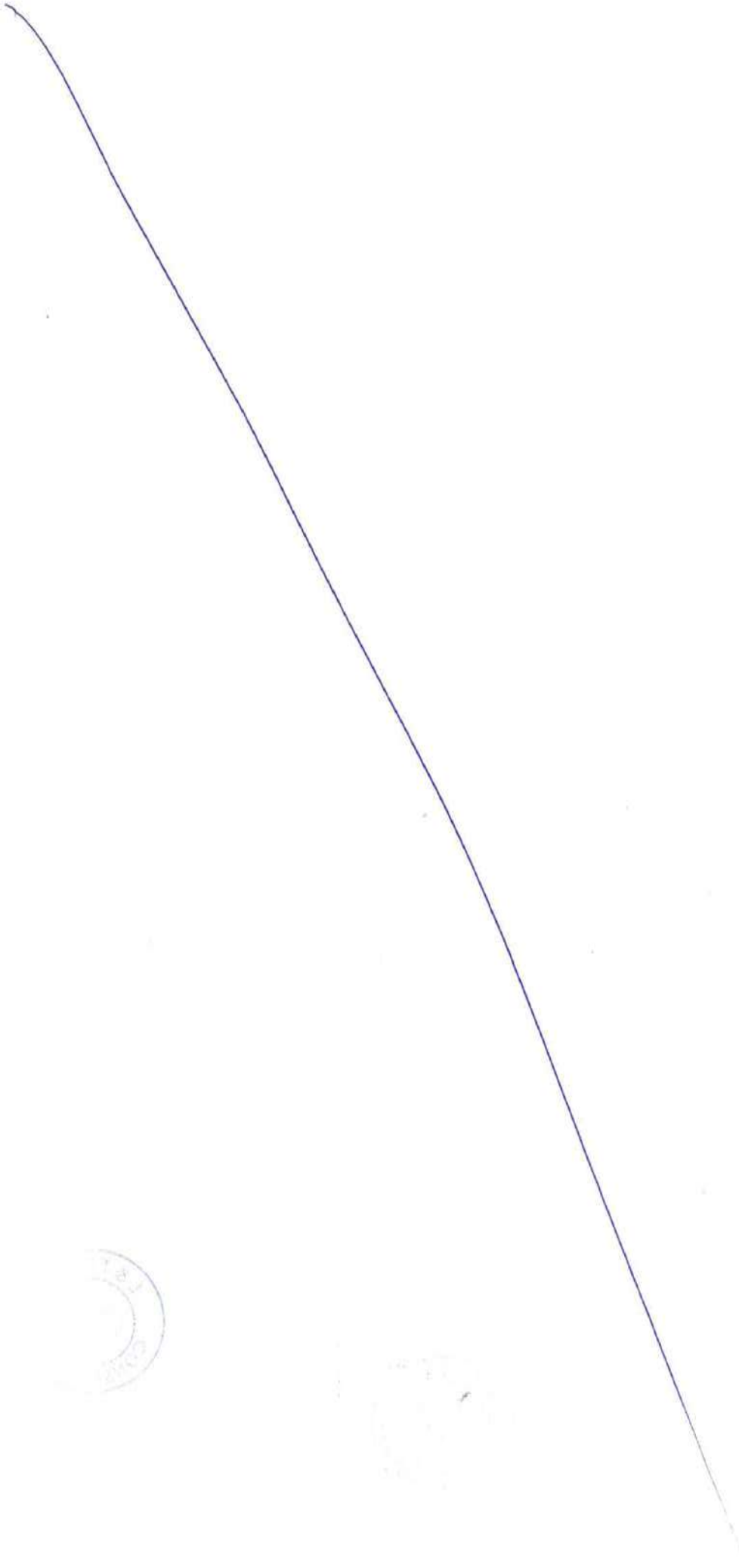
Corrective action taken as per proposal: YES / NO
Signature of Auditee : Actual closing date:
Objective Evidences for Corrective action and Closure
Review of corrective action & closing of NCR: *NCR reviewed & closed YES / NO* *Evidence to be attached if required* *Cost of reworks booked if required* Date

Minor Category NCR's

1. Can be easily corrected by auditee, such as incorrect completion of forms, or lack of attention to detail in a number of occasions.
2. Generally does not require training of staff
3. Can be corrected without cost to the Company
4. Can only be resolved through the issue of revised procedure text or content (not format) and associated documents.
5. Does not result in breakdown of system.

Major Category NCR's

1. Approval is not taken for any deviation from drawings / approved specifications/ITP/Procedure.
2. Could affect the business and/or integrity of the system.
3. Corrective action may cause significant costs to the Company
4. Requires overview by QMC to maintain system integrity
5. Results in breakdown of the system.



Quality Assurance Plan

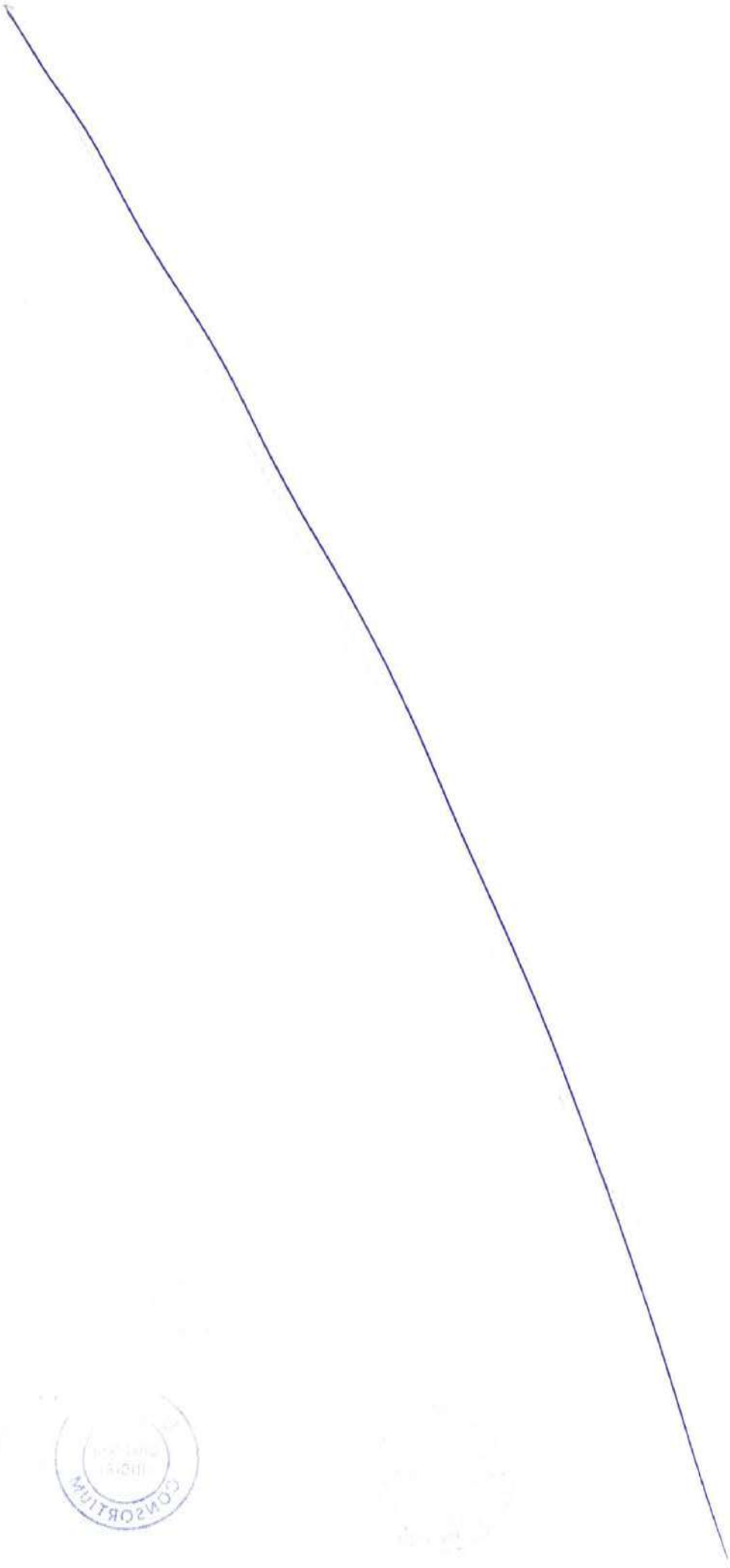
INSPECTION TEST PLAN

Sl. No.	Activity / Process	Characteristics to be checked	Method of Check	Quantum of Check	Ref. Doc. / Code		Acceptance criteria	Format of Record	Responsibility Vendor	L&T-IHI	Customer
									C	W/R	R/H

LEGEND: C – Check; W – Witness; R – Review, H- Hold

Prepared by :

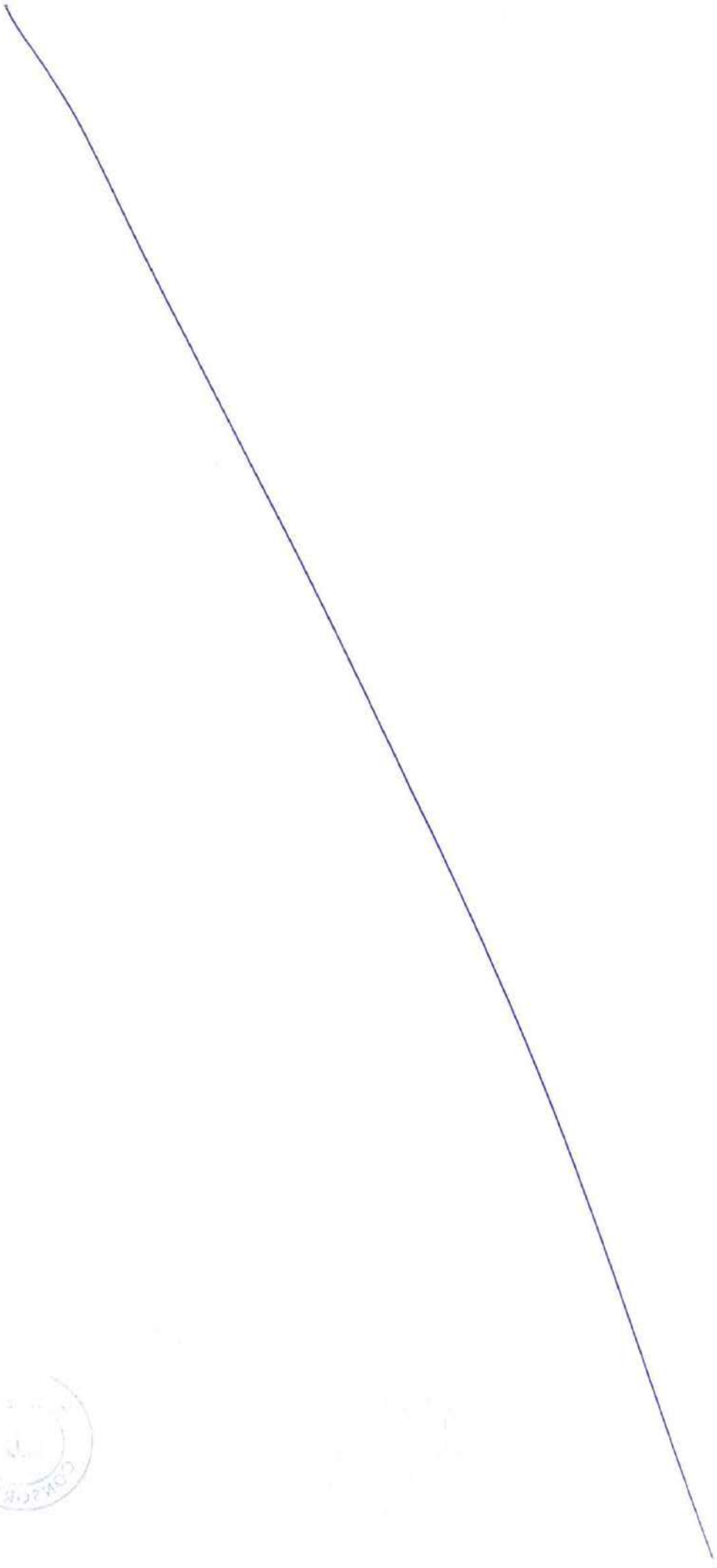
Approved by :



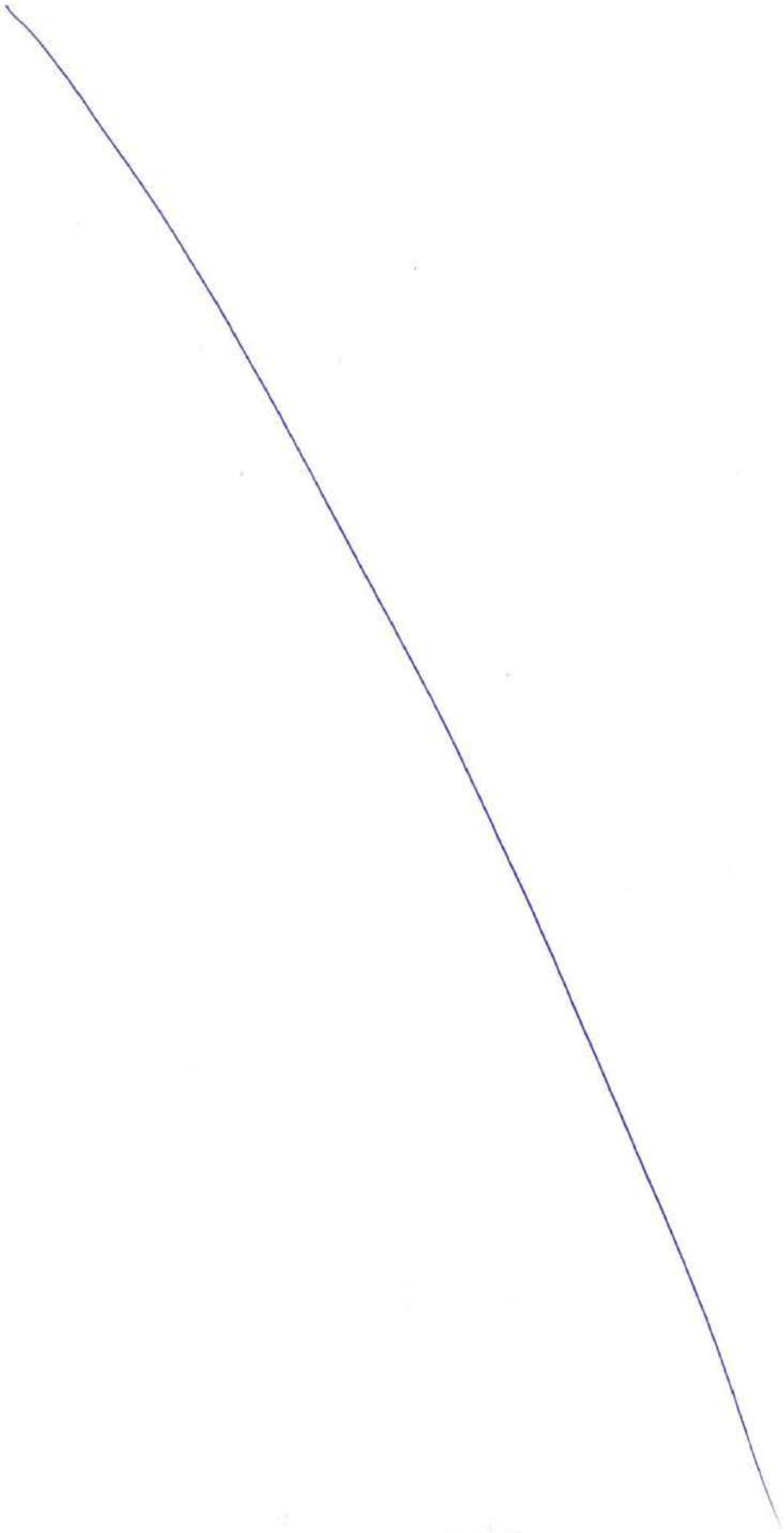
Quality Assurance Plan

Statutory Compliance Check List

SL No.	NAME OF THE ENACTMENT	Compliance status Yes/No/NA)
1	The Factories Act, 1948	
2	The Industrial Employment (Standing Orders) Act, 1946	
3	The Employment Exchanges (Compulsory Notification of Vacancies) Act, 1959	
4	The Industrial Disputes Act, 1947	
5	The Minimum Wages Act, 1948	
6	The Payment of Wages Act, 1936	
7	The Payment of Bonus Act, 1965	
8	The Payment of Gratuity Act, 1972 17	
9	The Equal Remuneration Act, 1976 18	
10	The Employees' Provident Funds & Miscellaneous Provisions Act, 1952	
U	The Employees' State insurance Act, 1948	
12	The Employees Compensation Act, 1923	
13	The Apprentices Act, 1961	
14	The Contract Labour (Regulation & Abolition) Act, 1970	
15	The Inter-State Migrant Workmen (Regulation of Employment and Conditions of Service) Act, 1979	
16	The Monopolies & Restrictive Trade Practices Act, 1969	
17	The Foreign Exchange Management Act, 1999	
18	The Foreign Trade (Development & Regulation) Act, 1992	
19	The Indian Boilers Act, 1923	
20	The Mines Act, 1952	
21	The Mines And Minerals (Regulation & Development) Act, 1957	
22	The Environment Protection Act, 1986	



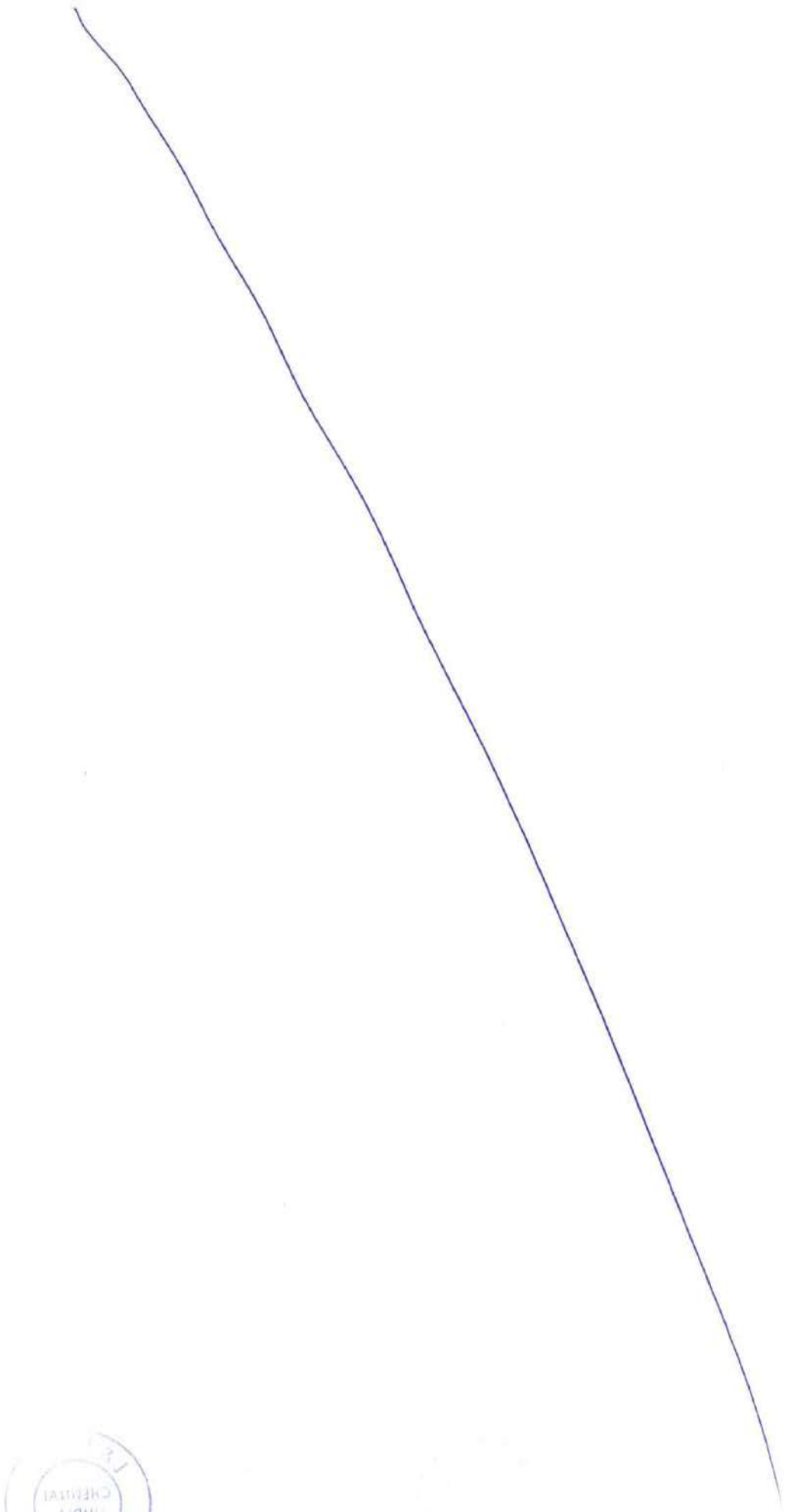
23	The Air (Prevention & Control of Pollution) Act, 1981	
24	The Water (Prevention & Control of Pollution) Act, 1974	
25	The Water (Prevention & Control of Pollution) Cess Act, 1977	
26	The Hazardous Waste (Management & Handling) Rules, 1989	
27	The Manufacture, Storage And Import Of Hazardous Chemicals Rules, 1989	
28	Income Tax Act, 1961	
29	The Central Sales Tax Act, 1956	
30	State Sales Tax / VAT Act	
31	State Tax on Professions	
32	The Central Excise Act, 1944	
33	Customs Act, 1962	
34	Service Tax, 1994	
35	The Bombay Shops & Establishments Act, 1948	
36	The Essential Commodities Act, 1955 65	
37	The Maharashtra State Tax on Professions, Trades, Callings and Employments Act, 1975	
38	The Public Liability Insurance Act, 1991	
39	The Personal Injuries (Compensation) Insurance Act, 1963	
40	The Petroleum Act, 1934	
41	The Petroleum Rules, 2002	
42	The Explosives Act, 1884	
43	The Static And Mobile Pressure Vessels (Unfired) Rules, 1981	
44	The Gas Cylinder Rules, 2004	
45	Information Technology Act, 2000	
46	The Bureau of Indian Standards Act, 1986	
47	The Maternity Benefit Act, 1961	
48	Maharashtra VAT Act, 2005	



Quality Assurance Plan

49	The Indian Telegraph Act, 1885 & The Indian Telegraph Rules, 1951	
50	The Telegraph Wires (Unlawful Possession) Act, 1950 & The Telegraph Wires (Unlawful Possession) Rules, 1951 & The Telegraph Wires (Permission for Sale and Purchase) Rules,	
51	The Indian Wireless Telegraphy Act, 1933	
52	The Research and Development Cess Act, 1986 The Research and Development Cess Rules, 1996	
53	Registration Act 1908	
54	Indian Stamp Act, 1899	
55	Motor Vehicles Act, 1988	
56	Bombay Labour Welfare Fund Act, 1948	
57	The Maharashtra Workmen's Minimum House Rent Allowance Act, 1983	
58	Indian Arms Act, 1959	
59	The Cigarettes and Other Tobacco Products (Prohibition of Advertisement and Regulation of Trade and Commerce Production, Supply and Distribution} Act, 2003	
60	The Unlawful Activities (Prevention) Act, 1967	
61	The Legal Metrology Act, 2009	
62	The Building and other Construction Workers* (Regulation of Employment and Conditions of Service) Central Rules, 1998	
63	The National Highways (Collection of Fees by any Person for the use of section of national highways/ Permanent Bridge/Temporary Bridge on National Highways) Rules,1997	
64	The Forest Conservation Act, 1980	
65	Bonded Labour System (Abolition) Act, 1976 107	
66	The Building and Construction Workers Welfare Cess Act, 1996 and The Building and Construction Workers Welfare Cess Rules, 1998	
67	The Child Labour (Prohibition and Regulation) Act, 1986	
68	Trade Union Act, 1926	

(Accounts & Admin In charge) **(Project In charge)**



Quality Assurance Plan

Scope of QMS

BU:

Project:

List of Departments

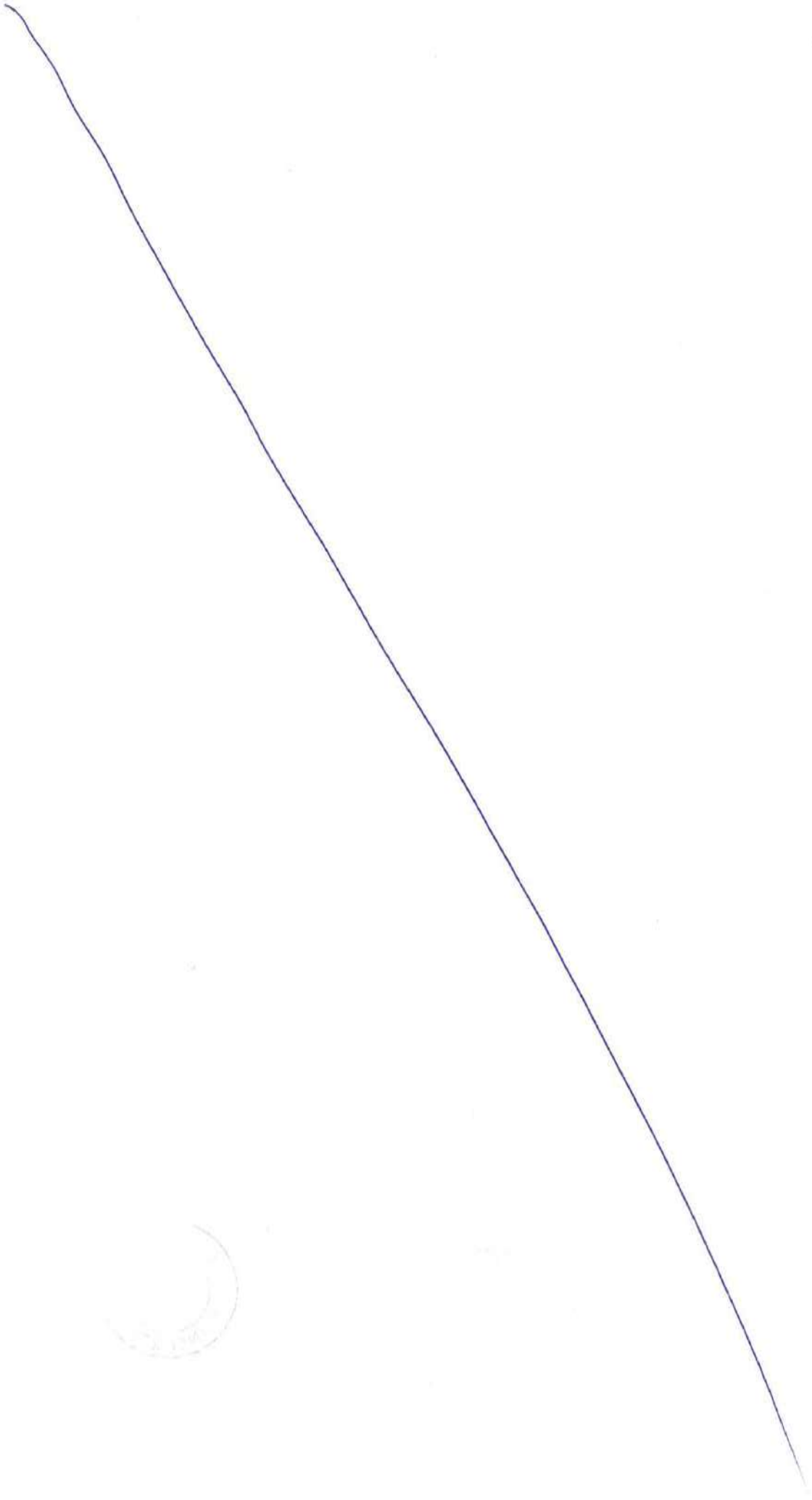
Sl.No	Departments	Remark

List of Specialized Agencies & External providers

Sl.No	Spl Agencies/ External providers	Remark

Project In charge Name & Sign :

Date :



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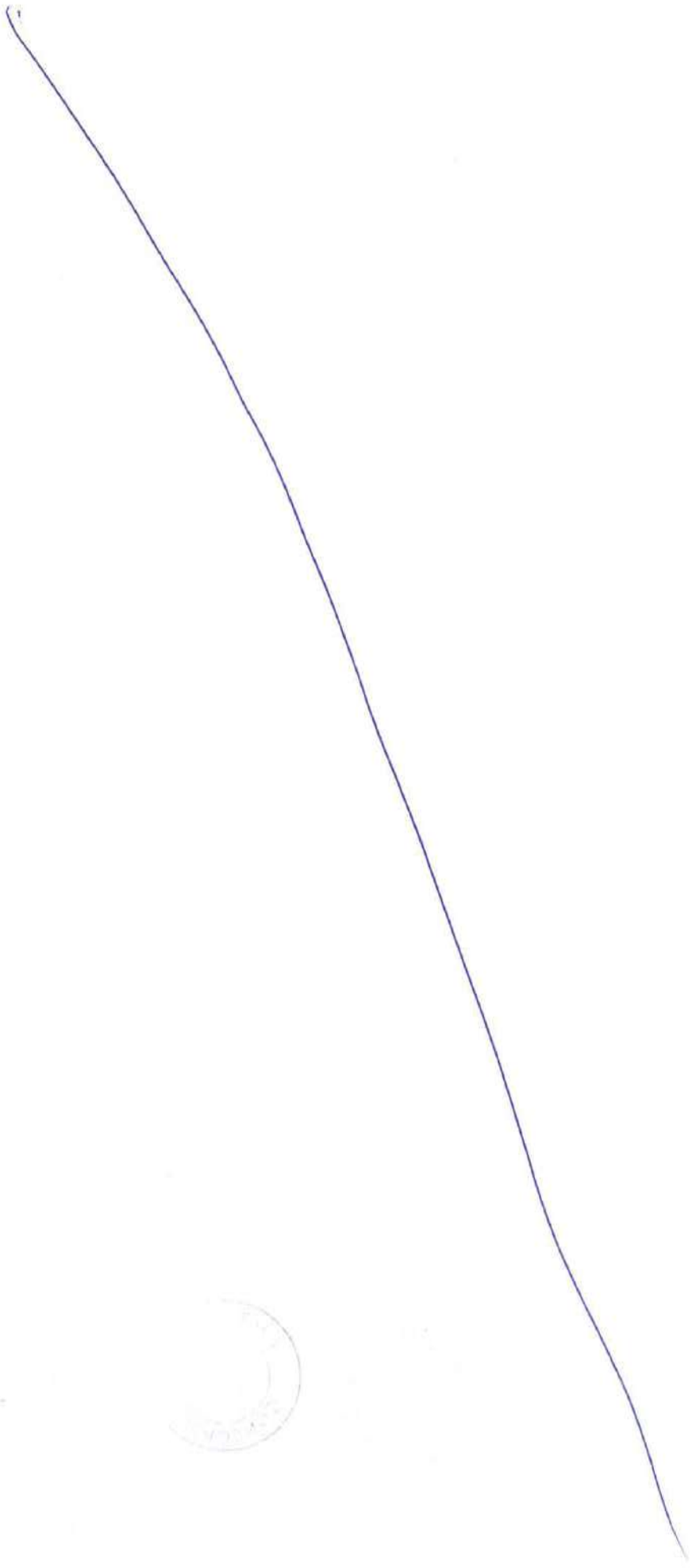
6001

Quality Assurance Plan

List of Identified Method Statements

Sl. No	Document No	Description
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		



L&T - IHI

Mumbai Trans Harbour Link Project (Package-1)

IFB No: MMRDA/ENG1/000752

Quality Assurance Plan

List of Identified ITP's

Sl No	Document No	Description
1		
2		
3		
4		
5		
6		
7		
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9		
10		
11		

L&T - IHI CHENNAI (INDIA) CONSORTIUM

MUMBAI METROPOLITAN REGION DEVELOPMENT AUTHORITY

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