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RISK MANAGEMENT IN METRO RAIL CONSTRUCTION

A Dissertation Submitted in Partial Fulfilment of the Requirements
For the Award of the Degree of Master of Technology
In
Construction Technology & Management

By

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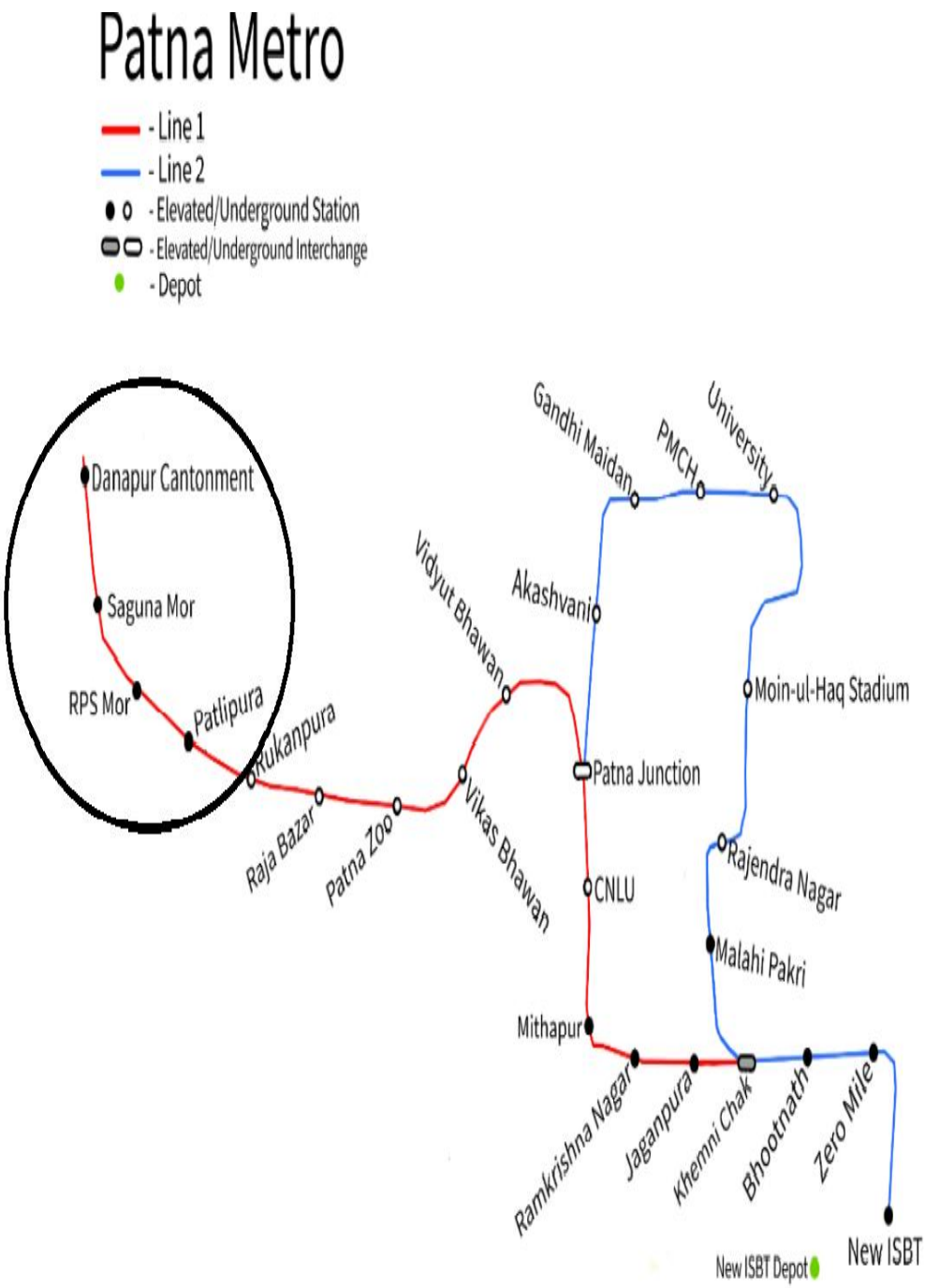

Abstract

This project deals with a method of measurement of project risk in metro construction. Project risk management primarily comprises cost and schedule uncertainties and risks associated with each activity of the project network. We have identified the major risk sources and quantified the risks in terms of likelihood, impact and severity in a complex infrastructure project for the construction of metro railways. A case study of the Patna Metro corridor PC-04 of phase-1 from Danapur to Patliputra in the capital city of Bihar has been considered for this project work. The methodology for this work is based on the response extracted from the experts who were associated and involved in this metro railway projects.

Managing risk and safety are critical activities in the increasingly complex metro rail environment. Demonstrating that risk and safety have been managed effectively is increasingly important in many rail regulatory regimes. Developing organization's competence in these areas will allow to improve the way risk and safety is managed within organization or projects, and also helps to meet regulatory and contractual requirements in an efficient and effective way.

Introduction

Project risk management is the art and science of identifying, analyzing, and responding to risk throughout the life of a project and in the best interests of meeting project objectives. Risk management is an essential and integral part of project management in major construction projects. For an infrastructure project, risk management can be carried out effectively by investigating and identifying the sources of risks associated with each activity of the project. These risks can be assessed or measured in terms of likelihood and impact. Depending upon the severity of each of the risks obtained, specific risk mitigation measures are proposed. It includes the recognition of potential risk event conditions in the construction project and the clarification of risk responsibilities. Risk identification develops the basis for the next steps: analysis and control of risk management. Corrects risk identification ensures risk management effectiveness. The responsible entity/authority of the project should take appropriate decision/action pertaining to the adoption of the mitigation measures for reducing the likelihood of occurrence of the identified risks involved in the project. Construction industry is a highly fragmented industry. It needs to communicate on a large scale with other related businesses such as material and equipment suppliers, vendors, subcontractors and clients. Now construction is becoming bigger and bigger and the risks involved are also increasing with a steady speed. Project Risk management is an essential and integral part of project management in major construction projects.

In this project report, Construction of Elevated metro of PATNA METRO of phase-1 from Danapur to Patliputra has been considered for formulation of Project Risk Management. The major activities consist of feasibility studies, design, traffic diversion, utility diversion, survey works, piling works, soil excavation, pile cap and pier works, pier caps ,U girder launching, waterproofing, permanent structure works, mechanical and electrical installations, backfilling and restoration works, etc.

Objective

- To identify, assess, monitor and manage risks (Risk Identification)
- To assess impact of risk (Risk Identification)
- To identify mitigative action (Risk Analysis)
- To control uncertain aspect of project (Control Risk Environment)
- To eliminate/transfer/reduce risks (Risks Response Planning)
- Risk severity and categorization.
- To identify the major risk factor in metro construction project through questionnaire survey.
- Assessment of the risk in terms of likelihood and impact.
- To create an efficient risk management system in the construction project.

Literature Review

1. Debasis Sarkar, Goutam Dutta [2011] ―A Framework of Project Risk Management for the Underground Corridor Construction of Metro Rail‖. In this paper, a method of measurement of project risk, based on the expected value method (EVM). They have identified the major risk sources and quantified the risks in terms of likelihood, impact and severity in a complex infrastructure project for the construction of an underground corridor for metro railways. For his research work he has taken an underground metro corridor in the capital city of an emerging economic nation of South Asia. The methodology for this work was the response from the experts associated and involved in this and other similar projects in metro rail. The risk analysis for the determination of risk cost, risk time, expected cost and expected time of the project has been carried out by the expected value method. Based on this study they found that the project cost overrun and time overrun can be about 22.5 % and 23.4 % respectively.
2. Prasant Kumar Dey, Management Decision 39/8 (2001) 634-649 – Decision support system for risk management - a case study.This study demonstrates a quantitative approach to construction risk management through analytic hierarchy process and decision tree analysis.All the risk factors are identified,their effects are quantified by determining probability and severity ,and various alternative responses are generated with cost implication for mitigating the quantified risks.The expected monetary values are then derived for each alternative ina decision tree framework and subsequent probability analysis aids the decision process in managing risks.the entire methodology is explained through a case application of a cross-country petroleum pipeline project in India an its effectiveness in project management is demonstrated.

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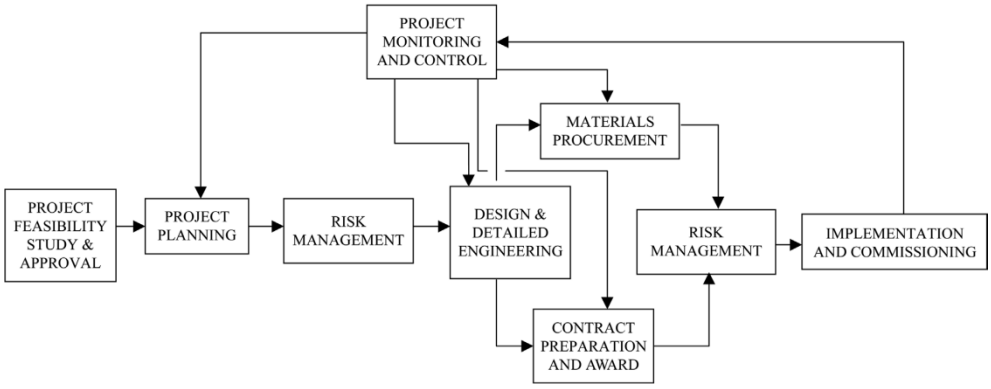
Proposed management model by Dey



Methodology adopted by Dey

I. Identifying the work packages for risk analysis.
II. Identifying the factors that affect the time, cost and quality achievement of specific work packages.
III. Analyzing their effect by deriving the likelihood of their occurrence in AHP (Analytical Hierarchy process developed Saaty in 1980) framework.
IV. Determining severity of failure by guestimation.
V. Driving various alternative responses for mitigating the effect of risk factors.
VI. Estimating cost of each alternative.
VII. Determining the probability and severity of failure of specific work package after specific response.
VIII. Forming decision tree.
IX. Deriving expected monetary value (EMV) (cost of risk response in this case) and
X. Selecting the best option through statistical analysis.

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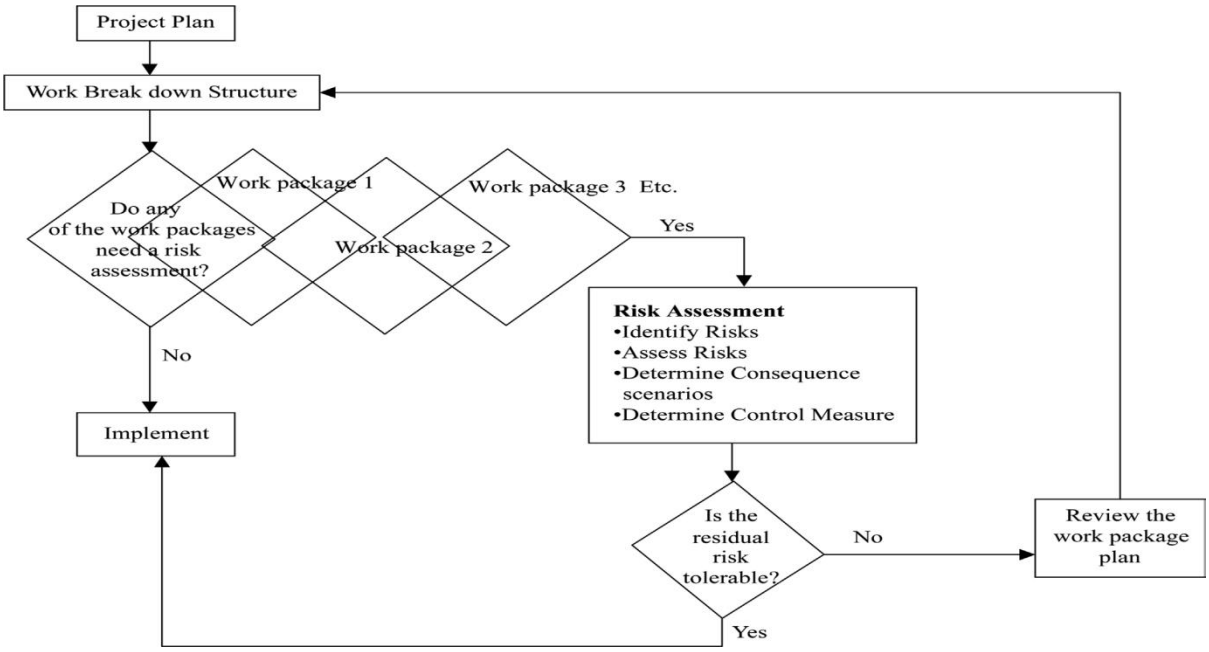
Risk Management Flow Chart by Dey



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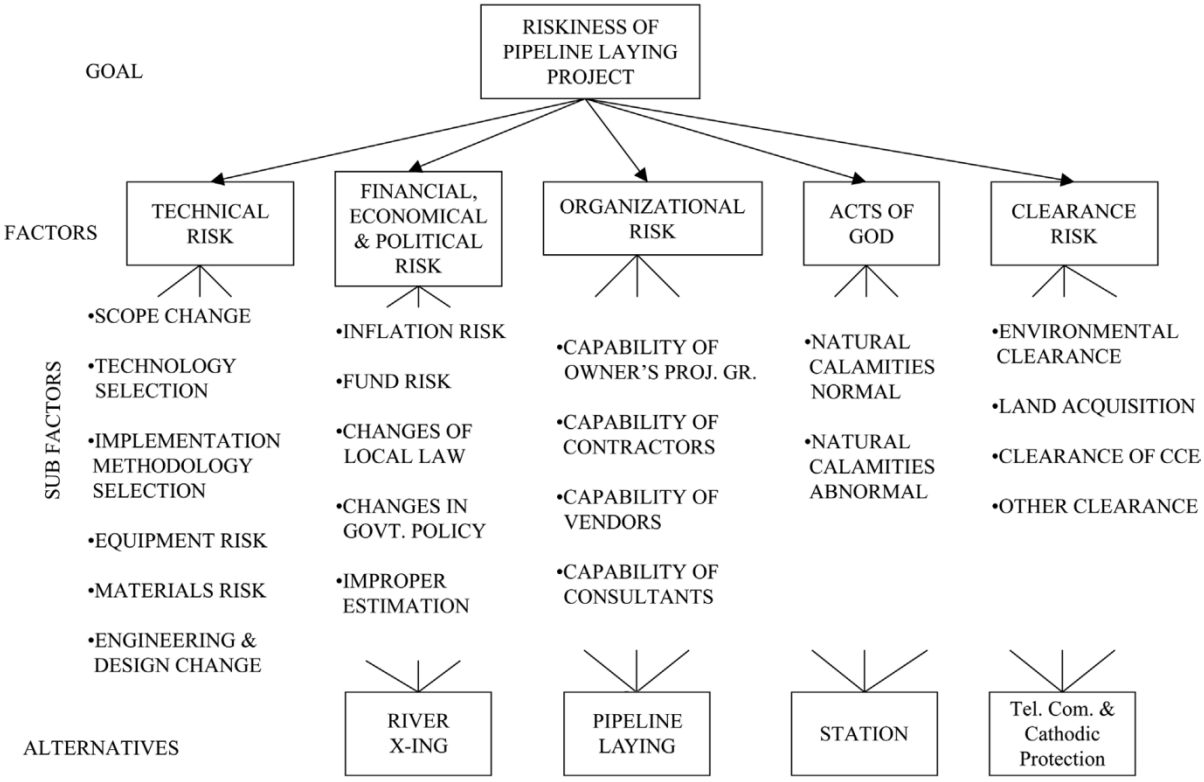
AHP model for determining riskiness of project



3. Williams, Walker and Dorofee (1997) worked on developing methods by which risk management could be put into practice. Their methods were based on software intensive programs (SEI) along with which specific road maps were designed. These could guide and help identify various risk management methods which could be easily put into practice Complex projects like the construction of an underground corridor for metro rail operations involve risks in all the phases of the project starting from the feasibility phase to the Operational phase. These risks have a direct impact on the project schedule, cost and performance.

4. Reilly (2005), Reilly and Brown (2004), Sinfield and Einstein (1998) carried out their research on underground tunnel projects. Reilly and Brown (2004) state that infrastructure underground projects are inherently complex projects with many variables including uncertain and variable ground conditions. As per Reilly (2005), for a complex infrastructure project like underground construction, it is very important to identify the risk events in the

early phases of the project. A proper risk mitigation plan, if developed for identified risks, would ensure better and smoother achievement of project goals within the specified time, cost and quality parameters. Further, it would also ensure better construction safety throughout the execution and operational phase of the project.

5. Anna Klemetti [5] explain that risk can be evaluated by estimating risk probability and impact in simple scales for example, from 1 to 5 or from high to low. The risks can be mapped in a probability – impact grid. On the grid, risk that require the most attention are easily detectable wherein actions to control them can be taken only if there are sufficient resources or if mitigating the risk costs are less than the product of possibility of risk's occurrences and its impact on project objectives (expected values).

6. Jannadi and Almishari (2003) attempt to assess risks associated with various construction project activities, defining risk as the potential damage that may affect personnel or property. They model risk by probability, severity of impact and 'exposure' to all hazards of an activity and provide software to generate risk scores. However, they do not provide a methodology for aggregating risk ratings. Similarly, Cagno et al. (2007) adopt the P-I model and quantify the 'risk load' allocated to each project element by identifying sources of uncertainty, activities affected, and risk owners. Risk impact is assessed in monetary terms but collectively as a single figure. They attempt to improve risk modelling by introducing the concept of 'controllability' as a ratio between the expected risk impacts before and after applying mitigation actions. Controllability is dealt with as a tool for justifying mitigation actions economically.

7. Baccarini and Archer (2001) present a methodology, adopted by the Department of Contract and Management Services in Western Australia, which ranks projects based on risk. The methodology utilizes the P-I model, which calculates a risk score for project cost, time or quality. Like

   previous models, although it considers different impacts on project objectives, it is an over-simplistic approach, averaging the likelihoods and the impacts of a risk on project cost, time and quality then multiplying them to generate a risk score. The final project risk score being the highest of the scores. The limitations of the various ways by which construction risk had previously been dealt with is discussed by Hillson (2002). He proposes assessing both threat and opportunity simultaneously within P-I models qualitatively and quantitatively.

METHODOLOGY

Collection of data: Collection of data is based on the survey and questionnaire of construction company namely - Delhi Metro Rail Corporation Limited and YFC-MCL (JV) , which includes the risk factors at the construction site. The data is collected from Delhi Metro Rail line - Construction of Elevated metro of PATNA METRO ,PC-04 of phase-1 from Danapur to Patliputra . The risk factor of questionnaire were based on different construction methods that are adopted in overhead metro construction such as Method of piling, construction of pile cap, construction of pier and pier cap, grade slab construction, casting of pier cap and U girder, launching of Pier Cap and U girder , stressing of Pier cap and U girder etc. covering risks as work at height , hit by person, hit by equipment , hit injury to workmen, road accident, improper handling of heavy reinforcement bars, transportation of girders from casting yard to site location, traffic control, launching of segments at night, shifting of launching truss, presence of unauthorized person . The mean and average value of the risk factors from the questionnaire survey is assessed in the form of risk severity and probability rating as High, Medium and Low. Risk Level is defined according to their severity from 1 to 5.

Having recognized the risk and evaluated probabilistic-ally its possible impact, the contractor will prepare appropriate risk management strategies and precautions. These strategies are usually based on the nature and likely consequences of the risk. The aim of these strategies is to eliminate as much as the possible impact and to increase manage of risk. With this in mind, the detailed construction methodology of different construction activities and their risk mitigation and control are discussed here.

METHOD FOR ERECTION OF PIER CAP, U GIRDER,T GIRDER AND PIE GIRDER

INTRODUCTION

The methodology describes erection and fixing of precast Pier cap, U girder,T girder,Pie girder for construction of elevated viaduct from chainage km.-12.998 to km.3181.96 & construction of four elevated stations on Danapur to Patliputra corridor of phase –I of PMRC MRTS.

PURPOSE

The purpose of this methodology is to describe the erection and fixing procedure of of precast Pier cap, U girder,T girder,Pie girder followed at site.

BRIEF METHOD OF CONSTRUCTION.

The precast of precast Pier cap, U girder,T girder,Pie girder units will be transported from the casting yard to the location with help of trailer. As the launching of of precast Pier cap, U girder,T girder,Pie

girder is progress ahead, the precast of precast Pier cap, U girder,T girder,Pie girder units will be placed with the help of a service crane or with the EOT or marsh crane as per the site condition by various capacity i.e 500T. The girders are shifted from trailer to feeder point with the help of 500 T capacity hydra crane of directly lifting with the help of EOT hoist as per the road clearance. Make sure that the girders will not be damaged during shifting from casting yard to erection location. Proper care shall be taken during placing on trailer also.

ERECTION PROCEDURE

The of precast Pier cap, U girder,T girder,Pie girder will be erected by crane/EOT or other suitable methods. The pier caps should be aligned as per General alignment of drawing (GAD) and U girders, T girders, Pie girders are lifted and placed on pedestal by taking proper co -ordinates and level.

Pier caps need to be stressed before erection of girders

After doing erection work the area and roads need to be cleared for movement of vehicle.

RISK INVOLVED.

a. Traffic
b. Working at height.
c. Trespassing of other workers in the working zone
d. Working with heavy equipment.
e. Settlement of base plate.

Safety precautions

a. Proper barricading should be done with suitable traffic signs (warning sign diversion sign) to avoid any vehicles on the road barging in to the working area.
b. The equipments will be operated within the safe working radius and all the equipments will be properly maintained and checked. No personnel will be allowed in the area of working / swing radius of the crane and other equipment.
c. All workers would be made aware regarding the methods of workers and safety awareness through toolbox talks.
d. Employing safe working practices.
e. Unenthorized / outside persons will not be allowed to enter inside /near during the erection of parapet and at the time of test.
f. All the workers will be provide with necessary safety equipments.

g. Availability of site first aid facilities.
h. Proper lighting arrangement during the night.
i. Dedicated and experienced safety officer and team will be deployed to ensure that erection shall be carried in safe condition.
j. Safe access will be provide in the for stair case which is erected for the safe access during the launching operations.
k. Formal risk assessment will be conducted and the suitable control measures will be identified and adopted.
l. Proper control measures as per SHE policy phase III version 1.2 will be adopted for the working at height hazard controls.
m. Operators, supervisors, safety staff and labour will be provided in house training in the form of Tool Box meeting on regular basis so that they can be aware of the risk involved and their control measures in the erection process.
n. Before doing any launching activity Plate Load test needs to be done.

Risk Assessment

Risk Assessment of Erection & Fixing of precast Pier cap, U girder,T girder,Pie girder	**SR =severity rating when it can lead to fatality of permanent disability or when property loss is more than Rs100,000**	**High= H**	**PR=Probability Rating- When it occurs frequently or Chances approx. more than 50%**	**3**	**4**	**5**
RL=-Risk Level, 1= Trivial , 2 =Tolerable, 3 = Moderate, 4 =substantial, 5 = Intolerable	**when it can lead to temporary disability or doctor visit is required or when property loss is more than 10,000 but less than 100,000**	**Medium=M**	**When it occurs occasionally or chances between 10% to 50%**	**2**	**3**	**4**
	When it can Lead to First aid Injury or	**Low=L**	**When it has never occured**	**1**	**2**	**3**

				When property Loss is Less than Rs 10,000			**before or Chances Less than approximately 10%**	**L**	**M**	**H**
SL NO	**Activity, Product, Service**	**Hazard,Concern**	**Severity Explanation**	**Severity Rating H/M/L**	**Probability Explanation**	**Probability Rating H/M/L**	**Risk Level 1/2/3/4/5**	**Risk Controls**		
								Existing/Required		
1	Loading/Unloading of of precast Pier cap, U girder,T girder,Pie girder on or from Trailer	Cuts, Bruise,serious injuries during material handling	Physical injury,Material Damage	L	Can Happen	M	2	a) Crane which will use for loading or unloading of parapet segment at both places (stacking yard & site) shall SWL should be more than lifting load and shall be certified by competent person. b) Trained Rigger & signal man Provided with Proper PPE's shall be engaged for loading unloading activity. c) Material shall be unloaded at defined, level surface and on wooden sleeper. d) Tools		

								and Trackle used for loading or unloading of material shall be certified and colour coded. e) During unloading of parapet working area shall be barricaded and such activity shall be carried out under supervision of senior person.

2	Transportation of of precast Pier cap, U girder,T girder,Pie girder from stacking yard to site	Cuts, Bruise,serious injuries during material handling	Physical injury,Material Damage	L	Can Happen	M	2	a) Trailer condition/ fitness shall be of good condition which will use for transportation of parapet. b) Parapet which is loaded for shifting shall be fully tied -up/ secured. c) Approach road condition shall be of good condition. d) Trailer speed shall be slow (Approx 5 or 10 KM /Hrs) During shifting of parapet. e) During shifting of parapet, Marshals/Trained Riggers shall control the traffic and such operation of senior person.

3	Erection/ fixing of of precast Pier cap, U girder,T girder,Pie girder on erected segment span.	Cuts, Bruise,serious injuries during material handling	Physical injury,Material Damage	L	Can Happen	M	2	a) Crane which will used for erection of parapet and fixing of supporting accesories shall be certified. b) Tools and Trackles which will use shall be certified and colour coded. c) Trained Riggers/Signal man provided with proper PPE's shall be engaged for Parapet Erection.
4	Alignment & jointing of of precast Pier cap, U girder,T girder,Pie girderunits.	Fall of person/ material from height	Physical injuri, Material damage	L	Can Happen	M	2	a) For fixing /jointing/Alignment of Parapet , proper supporting arrangement shall be provide b) All nut-Bolts of supporting arrangements shall be properly tightened. c) Area at ground level shall be barricaded and banks man shall be Provided to warn the unauthorized person. Trained Riggers shall be used for this activity.

5	Concreting of Jointing Portion	Fall/Tripping of person	Physical injuri	L	Can Happen	M	2	a) Trained workmen provided with proper PPE's shall be engaged for concreting work. b) concreting work shall be carried out in supervision of Engineer/foreman.
6	Dismantling of shutter and jacks	Cuts, Bruise, serious injuries during dismantling of staging jacks.	Physical injury, Material damage	L	Can Happen	M	2	a) Crane which will use for such activity shall be certified. b) Tool & Tackles which will use for such activity shall be certified and colour coded. c) Trained Riggers/ Signal man shall be engaged for dismantling of shutter and other accessories. d) Area at ground level shall be barricaded and banks man shall be provided to warn the unauthorized entry.

7	Work at height	Trips falling from height	Injury	M	May Happen	L	2	Proper access ladder provided for workers working at height and safety harness ensured and tied with fixed structure. Proper scaffolding provided. Safe working Platform Provided on the slab.

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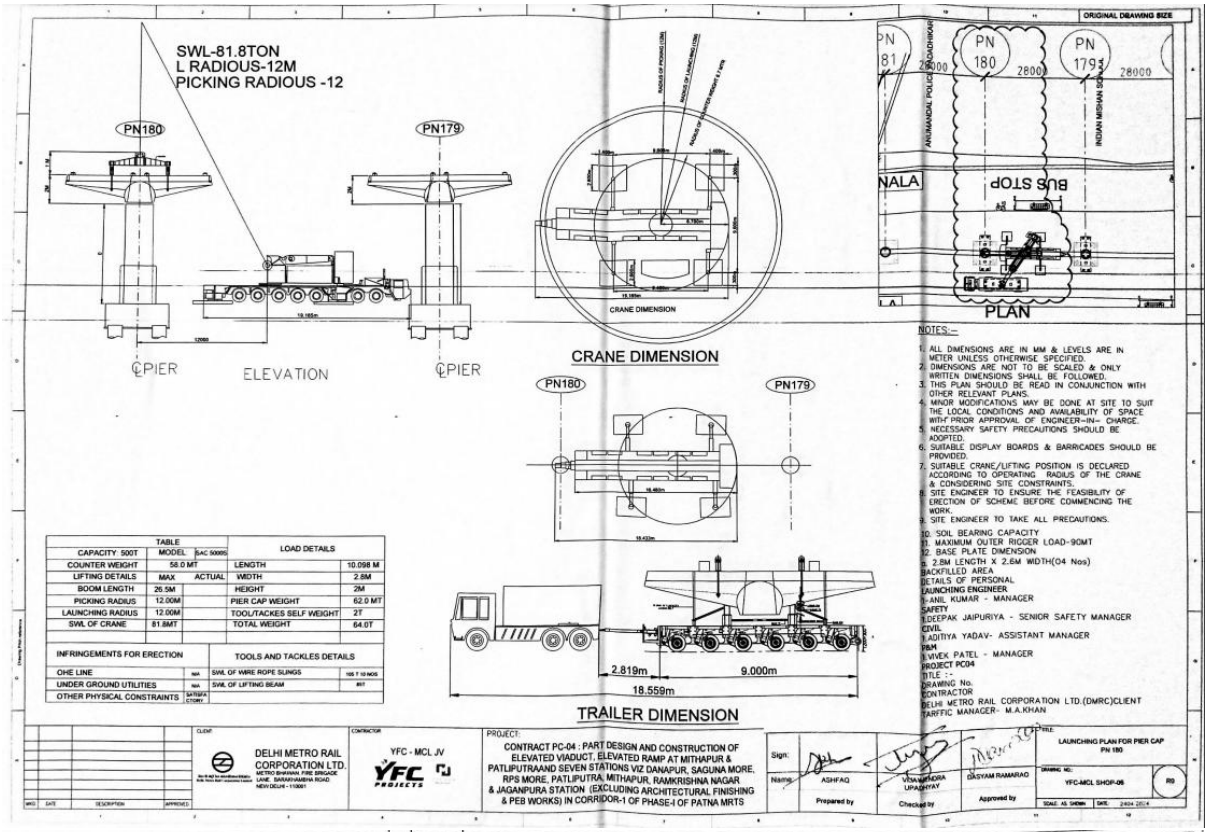

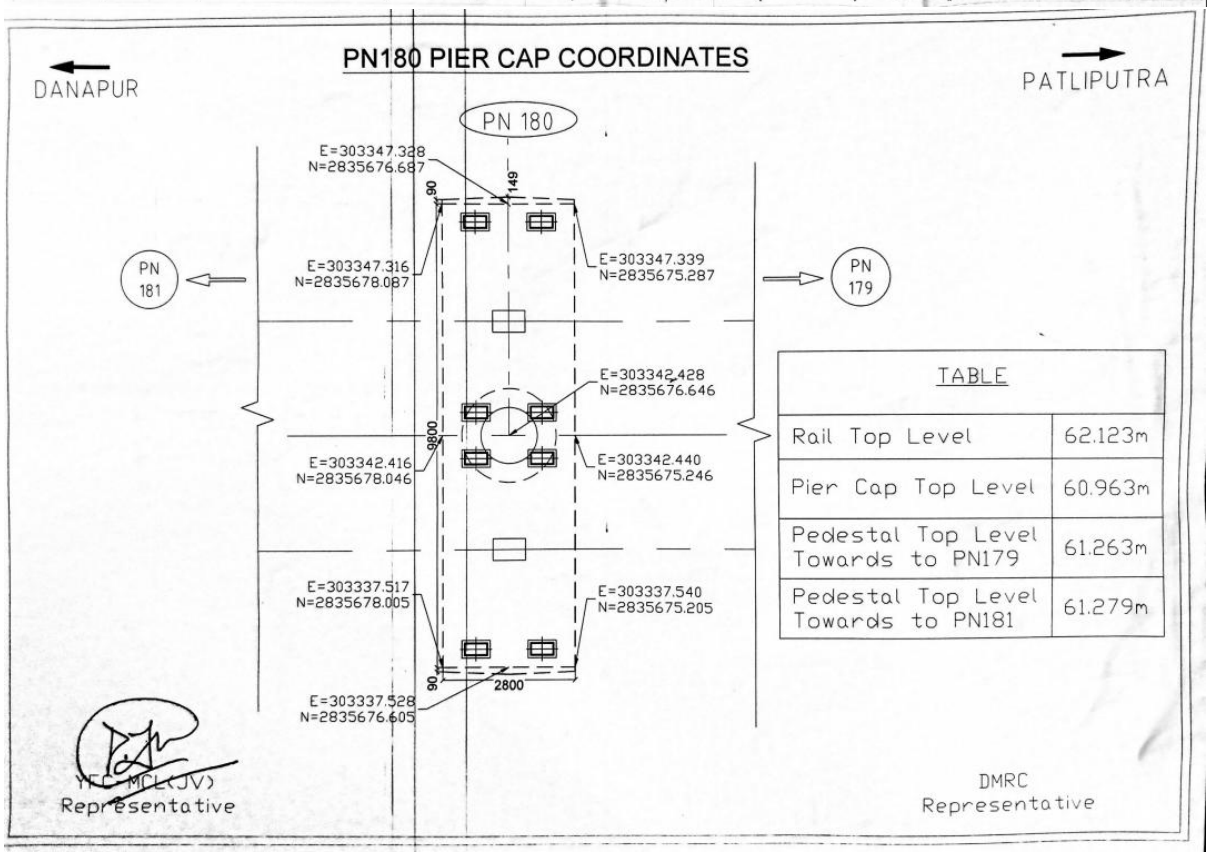

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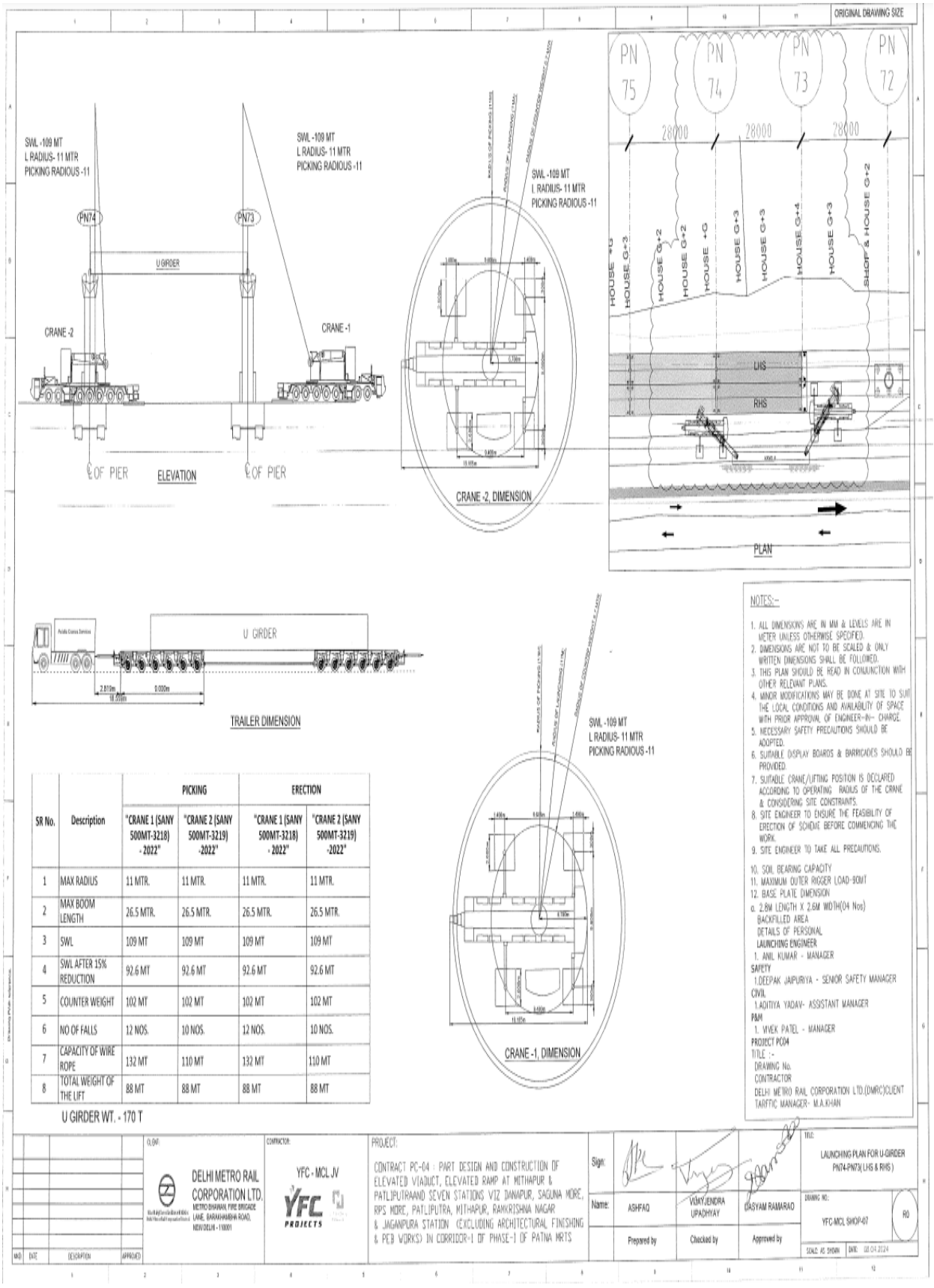

SR No.	Description	PICKING		ERECTION	
		"CRANE 1 (SANY 500MT-3218) - 2022"	"CRANE 2 (SANY 500MT-3219) -2022"	"CRANE 1 (SANY 500MT-3218) - 2022"	"CRANE 2 (SANY 500MT-3219) -2022"
1	MAX RADIUS	11 MTR.	11 MTR.	11 MTR.	11 MTR.
2	MAX BOOM LENGTH	26.5 MTR.	26.5 MTR.	26.5 MTR.	26.5 MTR.
3	SWL	109 MT	109 MT	109 MT	109 MT
4	SWL AFTER 15% REDUCTION	92.6 MT	92.6 MT	92.6 MT	92.6 MT
5	COUNTER WEIGHT	102 MT	102 MT	102 MT	102 MT
6	NO OF FALLS	12 NOS.	10 NOS.	12 NOS.	10 NOS.
7	CAPACITY OF WIRE ROPE	132 MT	110 MT	132 MT	110 MT
8	TOTAL WEIGHT OF THE LIFT	88 MT	88 MT	88 MT	88 MT

U GIRDER WT. - 170 T

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PLATE LOAD TEST

Contractor:	YFC-MCL JV
Client:	DMRC
Date of Testing:	21.03.2024
Testing Location:	PN-73 RK NAGAR

Plate Size=		600	X	600	Area of Plate	0.36	
Design Load=			25.0	Ton/m²			
Test Load=			62.5	Ton/m²			
Test Load as Per Plate Area=			22.50	Tonne			
Load Increment (Least of 1kg/cm² or 20% of test load)					4.5	MT	
Ram Dia	78.54 cm2						
1 Div. of Pressure Gauge (1 small Division x Ram Area)						0.7854 MT	
LC of Pr gauge		1 Div. = 0.7854 MT					
L.C of Dial Gauge		0.01 to 25 mm					

Desired Load (MT)	PR Gauge Reading (Div.)	Time (min)	Load, P (KN)	Stress (T/m²)	Dial Gauge 1	Dial Gauge 2	Settlement (mm)	Remarks
4.50	6	1	45.00	12.50	1.100	0.700	0.900	
		2.25	45.00	12.50	1.180	1.000	1.090	
		4	45.00	12.50	1.310	1.210	1.260	
		6.25	45.00	12.50	1.450	1.300	1.375	
		9	45.00	12.50	1.490	1.350	1.420	
		16	45.00	12.50	1.550	1.390	1.470	
		25	45.00	12.50	1.600	1.420	**1.510**	
9.00	11	1	90.00	25.00	2.400	1.900	2.150	
		2.25	90.00	25.00	2.600	2.100	2.350	
		4	90.00	25.00	2.700	2.200	2.450	
		6.25	90.00	25.00	2.780	2.220	2.500	
		9	90.00	25.00	2.820	2.260	2.540	
		16	90.00	25.00	2.900	2.300	2.600	
		25	90.00	25.00	2.950	2.390	**2.670**	
13.50	17	1	135.00	37.50	4.280	3.200	3.730	
		2.25	135.00	37.50	4.390	3.380	3.885	
		4	135.00	37.50	4.460	3.430	3.945	
		6.25	135.00	37.50	4.500	3.500	4.000	
		9	135.00	37.50	4.580	3.590	4.085	
		16	135.00	37.50	4.660	3.680	4.170	
		25	135.00	37.50	4.740	3.700	**4.220**	
18.00	23	1	180.00	50.00	4.780	3.710	4.245	
		2.25	180.00	50.00	4.790	3.710	4.250	
		4	180.00	50.00	4.800	3.720	4.260	
		6.25	180.00	50.00	4.820	3.730	4.275	
		9	180.00	50.00	4.830	3.750	4.290	
		16	180.00	50.00	4.860	3.790	4.325	
		25	180.00	50.00	4.880	3.800	**4.340**	
22.50	29	1	225.00	62.50	4.900	3.810	4.355	
		2.25	225.00	62.50	4.920	3.820	4.370	
		4	225.00	62.50	4.940	3.830	4.385	
		6.25	225.00	62.50	4.950	3.830	4.390	
		9	225.00	62.50	4.960	3.860	4.410	
		16	225.00	62.50	4.980	3.860	4.420	
		25	225.00	62.50	5.020	3.900	**4.460**	

Table of Load (P) vs Settlement (s)

Load (t)	Settlement (mm)	
0	0	0
12.50	1.510	-1.510
25.00	2.670	-2.670
37.50	4.220	-4.220
50.00	4.340	-4.340
62.50	4.460	-4.460

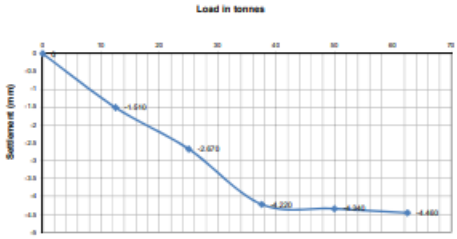
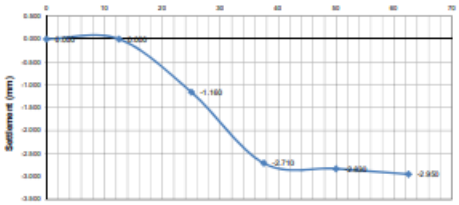
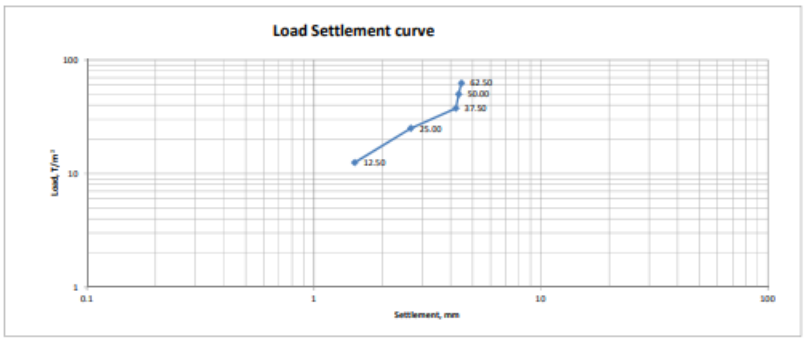


Table of Load (P) vs. Settlement (s) after zero correction

Load (t)	Settlement (mm)	
0	0.000	0.000
12.50	0.000	0.000
25.00	1.160	-1.160
37.50	2.710	-2.710
50.00	2.830	-2.830
62.50	2.950	-2.950





Note :-

Ultimate bearing capacity, q_u = Q/A
From normal plot, qu = 62.5 ton/m²

Safe Bearing Capacity (SBC)= 25.00 ton/m² **4.460** Settlement (mm)
(Safety of factor of 2.5 is taken)

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METHOD FOR CONSTRUCTION OF GRADE SLAB

INTRODUCTION

This method provides details of Construction of Grade slab at station location.

PURPOSE

This method deals with construction of grade slab with GSB filling, blinding concrete.

WORKSCOPE

The basic activities described in this method statement is for backfilling by suitable material, compaction of the fill material, blinding concrete will be carried out as per drawing then, grade slab concreting with reinforcement as mentioned in drawing.

MANPOWER

SL. No	Categories
1.	Carpenters
2.	Fitters
3.	Masons
4.	Helpers
5.	Operators
6.	Batching plant operators
7.	Safety stewards
8.	Equipment/ P&M helpers

CONSTRUCTION EQUIPMENT

Following equipments shall be used for casting of grade slab.

1. Batching Plant 60cum/ Hr -1 No
2. Batching Plant 30cum/Hr -1 No
3. JCB for material feeding -1 No
4. Transit mixer 4/6cum -3 Nos
5. Plate compactor -1 No
6. Needle vibrator (60/40mm) - 1 No
7. Diesel Generator -1 No
8. Concrete Pump /Bucket -1 No
9. Survey Instrument

TOOLS

1. Props for Supporting.

SAFETY MEASURES

a. Employing safe working Practices.
b. All workers would be made aware regarding the methods of work and safety awareness through toolbox talks.
c. Safety Harness.
d. (PPE's) used be & other arrangements

Risk Assessment of Erection & Fixing of Parapet				**SR =severity rating when it can lead to fatality of permanent disability or when property loss is more than Rs100,000**		**High=H**	**PR=Probability Rating- When it occurs frequently or Chances approx. more than 50%**	**3**	**4**	**5**
RL=-Risk Level, 1= Trivial , 2 =Tolerable, 3 = Moderate, 4 =substantial, 5 = Intolerable				**when it can lead to temporary disability or doctor visit is required or when property loss is more than 10,000 but less than 100,000**		**Medium=M**	**When it occurs occasionally or chances between 10% to 50%**	**2**	**3**	**4**
				When it can Lead to First aid Injury or When property Loss is Less than Rs 10,000		**Low=L**	**When it has never occured before or Chances Less than approximately 10%**	**1**	**2**	**3**
								L	**M**	**H**
SL	**Activ**	**Hazard,Co**	**Severity**	**Sever**	**Probabi**	**Probabi**	**Risk Level**	**Risk Controls**		

NO	ity, Product, Service	ncern	Explanation	ity Rating H/M/L	lity Explanation	lity Rating H/M/L	1/2/3/4/5	Existing/Required
1.	Barricading	Hit by Equipment	Physical injury	M	Can happen	L	2	Area should be barricaded before start the work
	Earth work excavation	Hit injury to workmen	Physical injury	M	Can happen	L	2	JCB equipped with reverse horn person working around the machine always faces the equipments. Access to machine controlled be concerned supervisor. Only authorized operators having valid license operate the machine.
	Earth Filling,	Hit by equipment	Physical injury	M	Can happen	L	2	Signal man should be available and unauthorized entry will not allow.
	Transit Mixer	Hit by person/ road accident	Physical injury	M	Can happen	L	2	Truck driver must be competent and experience deployed.
	Reinforcement Cutting bending and cutting	Improper handling of heavy reinforcement bar	Cut injury, Physical injury	M	Can happen	L	2	PPE's used and maintain good housekeeping working under super vision.

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METHODOLOGY FOR BORED CAST IN-SITU CONCRETE PILE

INTRODUCTION

This covers the methodology of piling work for foundations of the construction of Elevant Viaduct from Ch.KM.26.739 to KM.34.344 including entry exit line to depot, elevated ramp at Kalkaji & special spans and construction of six elevated stations. The proposed type of pile is 1200 mm dia. Bored cast in-situ concrete pile. The boring work for the pile will be done by Hydraulic Rotary Rig.

The objective of this method statement is to clearly understand the job and the step-by -step procedures of the piling work along with safety precautions, which is necessary to avoid to any kind of injuries/accidents to personnel to any damage to any equipments or property.

Purpose

The purpose of this methodology is to describe the procedure of piling work by using Hydraulic Rotary rig and the Bentonite slurry as stabilizing mud.

EQUIPMENT AND MATERIALS USED FOR CONSTRUCTION.

1. Survey instruments for layout setting of piles.
2. Hydraulic Piling Rig (MAIT/CASAGRANDE/Equivalent Make) for pile boring.
3. Boring bucket for 1200.
4. Steel casing of 1200mm inner diameter and the length of casing will be as per soil condition at site.
5. Bentonite plant comprising of mixing tank, water, pump, water tank, vertical pump, storage tank, settling tank, etc.
6. Diesel generator/power supply.
7. Steel reinforcement cage.
8. Transit mixers and batching plant/ RMC with slag/OPC.
9. 200/250mm dia. Tremie pipes and concreting funnel of 1.5 to 2.0 cum capacity.
10. Tyre mounted Crane/ 320 Crane for flushing and concreting.
11. Welding machine for welding of cage laps.
12. Sounding chain for checking & measuring the level of bore hole.
13. Excavator/loader for handling of muck.
14. Tripper for muck disposal.

SAFETY PRECAUTIONS

a. Working area should be properly barricaded.
b. All site personnel shall be provided with safety helmet, safety jackets, safety shoes and other personal safety devices as required.
c. Traffic marshals shall guide the traffic during progress of work.
d. Traffic shall be diverted as per approved scheme wherever and whenever required..
e. Swing area of the rig should be barricaded or demarcated.
f. Ground stability / levelling will be checked before rig.
g. Overhead electric cables and wires to be checked before marching / swing of rig.
h. All swing alarms and swing lights should be in working condition.
i. Pile bore muck should not be staked too high.
j. Pile cage/ muck not to be loaded on the barricades.
k. All idle pile bores should be covered with grating.

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METHODOLOGY FOR CAST IN-SITU PILE CAP

INTRODUCTION

This method statement covers the methodology of pile cap for foundation of the constructions of Elevated Viaduct from Ch.KM.26.739 to KM.34.344 including entry exit line to depot, elevated ramp at Kalkaji & special spans and construction of six elevated stations.

The objective of this method statement is to clearly understand the job and the step-by-step procedure of the construction of pile cap along with safety precautions, which are necessary to avoid any kind of injuries/ accidents to personnel and any damage to any equipment or property.

PURPOSE

The purpose of this method statement is to describe the procedure of construction of cast In-Situ pile cap using shutter and supporting arrangement.

EQUIPMENT AND MATERIALS USED FOR CONSTRUCTION.

1. Survey instruments for layout setting of pile cap.
2. Batching plant / RMC with OPC.
3. Transit mixer
4. Needle vibrator.
5. Welding generator.
6. Jack Hammer.
7. Compressor
8. Crane
9. Dewatering pump.
10. Excavator for excavation of earth.
11. Tripper for earth disposal
12. Static concrete pump
13. Static concrete pump (stand by)

SAFETY PRECAUTIONS

a. Working area should be properly barricaded.
b. All site personnel shall be provided with safety helmet, safety jackets, safety shoes and other personnel safety devices as required.
c. Traffic marshals shall guide the traffic during progress of work.
d. Traffic shall be diverted as per approved scheme wherever and whenever required.
e. The excavator will be operated within the safe working radius and all the equipments will be properly maintained and checked. No personnel will be allowed in the area of working/swing radius of the crane and other equipment.

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METHODOLOGY FOR CAST IN-SITU PIER & PIER CAP

INTRODUCTION

This method statement covers the methodology of pier cap of the construction of Elevated Viaduct from Ch.KM.26.739 to KM.34.344 including entry exit line to depot, elevated ramp at Kalkaji & special spans and construction of six elevated station.

The objective of this method statement is to clear understand the job and the step-by step procedures of the construction of pier cap along with safety precautions which are necessary to avoid any kind of injuries/ accidents to personnel and any damage to any equipments or property.

PURPOSE

The purpose of this method statement is to describe the procedure of construction of cast In-Situ pier & pier cap using shutters and supporting arrangement.

EQUIPMENT AND MATERIALS USED FOR CONSTRUCTION

1. Survey Instrument for layout setting of pier &pier cap.
2. Batching Plant / RMC with OPC,-2 Nos.
3. Transit mixer
4. Needle vibrator
5. Welding Generator
6. Crane of suitable capacity
7. Concrete pump/Boom Placer (Static pump for standby).

SAFETY PRECAUTIONS

a. Working area should be properly barricaded.
b. All site personnel shall be provided with safety helmet, safety jackets, safety shoes and other personnel safety devices as required.
c. Traffic marshals shall guide the traffic during progress of work.
d. Traffic shall be diverted as per approved scheme wherever and whenever required.
e. The excavator will be operated within the safe working radius and all the equipments will be properly maintained and checked. No personnel will be allowed in the area of working/swing radius of the crane and other equipment.

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f. Proper safety railing must be provide when working on the height.

METHODOLOGY FOR MINOR REPAIR/RENDERING OF SEGMENTS

INTRODUCTION

The method statement covers the methodology of repair, restore and rendering of minor defects of segment casted at our CC-15 Casting yard. The objective of this method statement is to clear

understand the job and the step-by step procedures of the restoring, repairing and rendering with safety precautions which are necessary to avoid any kind of injuries/ accidents to personnel and any damage to any equipments or property.

PURPOSE

The purpose of this method statement is to describe the procedure of conducting minor repair, rendering and restoration of segment at inner and outer face.

EQUIPMENT AND MATERIALS USED FOR CONSTRUCTION.

1. OPC cement :- As primer over the concrete.
2. CONBEXTRA GP-2 ,ATGROUT :-For Non shrink repair Making Mortar.
3. Trowel
4. Brush the width 100 mm.
5. Mixing Pan of capacity 5 kg.
6. Medium density foam pad or jute Rag.

SAFETY PRECAUTIONS

a. Working area should be properly barricaded.
b. All site personnel shall be provided with safety helmet, safety jackets, safety shoes and other personnel safety devices as required.

METHODOLOGY FOR WIDENING OF EXISTING ROAD

INTRODUCTION

This method statement covers the methodology of widening of existing road at all the location wherever it is required.

PURPOSE

The purpose of this method statement is to describe the procedure of widening of existing road for accommodating the piling machinery and the safe movement of traffic.

EQUIPMENTS AND MATERIALS USED FOR CONSTRUCTION

1. Survey Instrument for maintaining Levels and alignment.
2. Excavator for dismantling and excavation of existing road.
3. Static/ Vibratory roller for compaction.
4. Tippers for transportation.
5. Tractor Grader for grading and leveling.
6. Drum type Hot mix plant for mixing of BM.
7. Paver/ hand tools for spreading of bituminous material.

SAFETY PRECAUTIONS

a. Working area should be properly barricaded.
b. All site personnel shall be provided PPE.
c. Traffic marshals shall guide the traffic during progress of work.
d. Traffic shall be diverted as per approved scheme wherever and whenever required.

METHOD STATEMENT FOR FEEDING AND WEIGHING OF MICROSILICA /ALCOFINE FOR M-60 GRADE OF CONCRETE

INTRODUCTION

This method statement covers the methodology for feeding of ultrafine MICROSILICA / ALCOFINE in CP-30 (30 cum capacity concrete batching plant) with all the safety precaution and accuracy. The method includes the reflection of quantity on concrete batch sleep.

PURPOSE

The purpose of this method statement is to describe the procedure of feeding, measuring and taking print out of quantity of power MICROSILICA on concrete batching sleep.

EQUIPMENT AND MATERIALS USED FOR CONSTRUCTION.

a. CP-30 Batching plant

b. S.S.Storage tank of capacity 100 Kg.

c. Screw conveyor with SS Lining.

d. Electronic Load cell of accuracy 0.10 Kg.

e. Software for controlling mixing sequence and weighing.

SAFETY PRECAUTIONS

a. Feeding area should be properly enclosed.

b. All site personnel shall be provided with PPE.

c. Proper stacking and covering of materials should be ensured.

HAZARDS IDENTIFICATION

Not regarded as a health or environmentaI hazard under current legislation.

COMPOSITION/INFORMATION ON INGREDIENTS

FIRST-AID MEASURES

GENERAL INFORMATION

Move The exposed person to fresh air at once.

INHALATION

Move the exposed person to fresh air at once.

INGESTION

Immediately rinse mouth and drink plenty of water (200-300 ml).

SKIN CONTACT

Wash skin thoroughly with soap and water.

EYE CONTACT

Immediately flush with plenty of water or eyewash solution for up to 10 minutes.

FIRE-FIGHTING MEASURES

EXTINGUISHING MEDIA

The product is non combustible.

SPECIAL FIRE FIGHTING PROCEDURES

No specific fire fighting procedure given.

ACCIDENTAL RELEASE MEASURES

PERSONAL PRECAUTIONS

Wear protective clothing

ENVIRONMENTAL PRECAUTIONS

Avoid spreading dust or contaminated materials

SPILL CLEAN UP METHODS

Avoid generation and spreading of dust. Collect in containers and seal securely.

HANDLING AND STORAGE

USAGE PRECAUTIONS

Read and follow manufacturer's recommendations.

STORAGE PRECAUTIONS

Store away from Acids. Store In tightly closed original container in a dry, cool and well-ventilated place.

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METHODOLOGY FOR PRECASTING OF SEGMENTS FOR SUPERSTRUCTURE

INTRODUCTION

This method statement covers the methodology and construction sequence for' casting of Pier cap, U girders, T girder, Pie girder of the Construction of Elevated Viaduct from Danapur to Patliputra PC-04 Patna Metro project

The objective of this method statement is to c1eai'1y understand the job and the step-by-step procedures of the casting of segments along with safety precautions, which are necessary to avoid any kind of injuries / accidents to personnel and any damage to any eqriipments oi- property.

PURPOSE

The purpose of this method statement is to describe the construction procedure to be followed at the site and is in the line of technical specifications of contract document.

EQUIPMENT USED FOR CONSTRUCTION.

SI. No.	DESCRIPTION	TYPE	CAPACITY'	Nos.
1	Goliath gantry For Bay-1	EOT	60T	1
3	Goliath gantry For Bay- 2	EOT	60T	1
5	Static Concrete Pump Boom placer (Standby)	$*? Putmizer	30 cum/hr. 60 cum/hr	2 1
6	Batching Plant	Stetter Stetter	30 cum/In. 60 cum/hr.	1 1
7	Transit Mixers	Stetter	6 cum.	3
8	Concrete Needle Vibrators	Poker		6
10	Shutter Vibrators	Waker		2 x 4
11	Compressor	Internal		2

MATERIAL USED FOR CONSTRUCTION

- Reinforcement Steel
- MS plates / Segment Mould / Shutter
- Concrete M-45 / M-6- grade
- MS Sheathing / Pre-Stressing Ducts

SAFETY PRECAUTIONS

a. All site personnel shall be provided with safety helmet, safety jackets, safety shoes and other personal safety devices as required.
b. Suitable lighting shall be provided at specific location to enhance visibility at night.
c. For other activities such as welding handling of reinforcement, electrically operated equipments etc. safety devices/precautions shall be taken as per the approved safety plan.
d. Proper safety railing iniist be provided when working on the height.

METHODOLOGY PLATE LOAD TEST
INTRODUCTION

This method statement covers the methodology of Plate load test on original ground / compacted ground with help of loaded truck using 300X300 mm test plate. Test arrangement will cater for additional 25% above test load.

Size of Plate	Design Load (MT)	Test Load (MT)	Test arrangement cater for (MT)
300X300 mm	1.8T	5.4T	10T

PURPOSE

The purpose of this method statement is to describe the procedure of Plate load test by using loaded truck.

EQUIPMENT AND MATERIALS USED FOR CONSTRUCTION.

Following equipments / accessories will be used for conducting load test:

1. Plate 300X300mm 25mm Thick
2. 25 T Capacity Hydraulic Jack.
3. Truck
4. Dial Gauge

BRIEF METHOD OF CONSTRUCTION

It is proposed to conduct plate load test to establish the observing settlement of soil at original ground. After finalization of the location of test, the same shall be constructed as per method statement. Plate test will be conducted on original ground. Test arrangement will be done as per drawing shown. The test should be carried out by applying a series of vertical downward incremental load, each increment

being about 10 percent of safe load on Plate. Settlement shall be recorded with 4 dial gauges of 0.01 mm least count and held by datum bars resting on immovable supports at a distance of 3D (subject to min of 1.5m).

JOB BREAK DOWN

Survey

After finalization of the location and cut off level by client for test pile, survey will be done,

concrete pedestal position will be marked.

Test arrangements

1. Compact the backfilling material in loose layer thickness of 25mm with plate compactor, so as to get compacted layer thickness of 150mm for each layer.
2. If required, some excavation may have to be done at the test location, to accommodate test arrangement, beneath the rear axle of truck. This excavation may be of 500mmX500mm in plan and 150-200mm in depth.
3. Place 300mm X 300mm X 25 mm (Thick) test plate at desired test location.
4. Place 250mm X 250mm X 25mm (Thick) plate on top test place concentrically.
5. Place 200mm X 200mm X 25mm (Thick) plate on top of 250mm X250mmX 25mm plate concentrically.
6. Bring a dumper/TM (minimum laden weight of 20T) and park it so that rear axle is positioned, centrally above the 3 plates arranged at the test location.
7. Put 25T/50T capacity hydraulic jack centrally on top of 200mm X 200mm plate.
8. Put packing plates between top of hydraulic jack and underside of central part of rear axle of parked truck.
9. Place 1.5 to 2.0 m long datum bars with proper supports symmetrically on either side of test plate.
10. Place 4 nos of Dial gauges of 50 mm range x 0.01 mm LC, symmetrically at 4 corners of test plate, to measure settlement.

11. Connect hydraulic jack to hydraulic pump and apply some nominal pressure to make perfect contact between hydraulic jack & underside of axle.

12. Note down initial readings of all 04 Dial gauges.

13. Note down RAM area of hydraulic jack and apply calculated amount

14. Application of pressure with hydraulic pump, as indicated in the table shown below. Use a pressure gauge of 200 KG/CM2 least count.

Test sequence

1. Apply load in a proper sequence in steps as shown.

PRESSURE ON PLATE	10 T/M2	15 T/M2	20 T/M2	25 T/M2	30T/M2	35 T/M2	40 T/M2	45 T/M2	50 T/M2	55 T/M2	60 T/M2
LOAD	0.9T	1.35T	1.8T	2.25T	2.7T	3.15T	3.6T	4.OT	4.5T	4.95T	5.4T

2. Maintain each load for a period of 10 minutes and take observations of settlement at 1 minute, 5 minutes and 10 minutes for each loading step of all 4 dial gauges.
3. After reaching final load, do unloading in following manner:

Pressure on plate	60 T/M2	50 T/M2	40 T/M2	30 T/M2	20 T/M2	10 T/M2	0 T/M2
Load	5.4 T	4.5 T	3.6 T	2.7 T	1.8 T	0.9 T	0 T

4. During unloading, maintain each load for- 10 minutes and take readings of settlement at 5 minutes for each unloading step of all 04 gauges.
5. After completion of test, remove hydraulic jack, pump, test plates, dial gauges, datum bar etc., and store in a safe place.
6. Remove the parked truck safely.

Result

From the readings of 3 dial gauges, average settlement under each increment of load will be calculated. From results of average settlements, graph of applied time load versus settlement will be plotted along with Pile data.
Total Settlement, Net Settlement and Elastic Rebound of pile will be worked out. The following information will be included in the

Test report

- Description of soil conditions, ground water table, actual boring and installation Records, concrete cube Test results.
- Method of Load application.
- Load settlement readings during Loading
- Time Load settlement curve
- Any other observation relevant to the test being conducted.

RISK INVOLVED

- Interference or presence or unauthorized person inside the area during work.
- Sudden increase in application of Load.
- Failure of leeks.

SAFETY PROCEDURE

The area for plate load test will be temporarily barricaded.

Unauthorized / outside persons will not be allowed to enter inside/near the test assembly during the preparation for plate test and at the time of test.

All the workers will be equipped with necessary safety equipments.

Ensure truck is locked during conducting the test.

The safety personnel will be present throughout the period of test to prevent any lapse in Safety.

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Risk Analysis - Plate Load test By Truck

S.No.	Activity Product or Services	Type of Hazard	Condition Normal/Abnormal/Routine/Non routine/Emergency	List of potential injuries	Function exposed to Hazard	Control Measures	RISK EVALUATION :						Regula tions
							Business concern		OH & S Concern				
							L	I	S	P	D	Risk No	
1	Plate load test by loaded truck												
		Toppling of truck while giving load due to land settlement	Emergency	Fracture, disability, death	Worker ,public ,operator	Ground to be well compacted before giving load	5	1	5	2	5	72	Rule 54 of BOC WCR
	Interference of unauthorized person	Hit by truck or hydraulic jack	Abnormal	Physical injury	Worker	Area should be barricaded & deployment of security guards, supervision under Engineer & safety personnel	5	1	3	3	3	54	Rule 97 of BOC WCR
	Fixing of Hydraulic Jack	Trap in between Jack & truck	Abnormal	Physical injury	Worker	Supervision, use of PPEs, Good Housekeeping to be	5	1	3	3	3	3	Rule 97 of BOC WCR

						maintained, safe work access							
	Plate Load test by Hydraulic mechanism	Hydraulic hose busted due to improper handling, tightening for temp., pre-stressing	Abnormal	Injury, fracture, death	Worker, operator	Preventive maintenance of jacks, pumps, and calibration gauges	1	1	4	1	5	20	

Where S = severity , P = Probability , L = Legal , I = Interested Party

Methodology for conducting Geo technical Investigation

INTRODUCTION

This method statement covers the methodology of geo technical investigation and report preparation for ascertaining the soil properties for design of foundations for the Construction of Elevated Viaduct from CH.KM.26.739 to KM.34.344 including entry exit line to depot, elevated ramp at Kalkaji & Special spans and construction of six elevated stations.

The objective of this method statement is to clearly understand the job and the step-by-step procedures of the geotechnical investigation along with safety precautions, which are necessary to avoid any kind of injuries/accidents to personnel and any damage to any equipments or property.

PURPOSE

The purpose of this method is to describe the procedure of field investigations and test, laboratory test, analysis and interpretation of data and results to be followed during geotechnical investigation.

EQUIPMENTS

Following equipments/accessories will be used for Geotechnical Investigation work:

- Shell & Auger Rigs with Power Winch and all accessories
- Casing Pipe 6” ID
- Drilled Rod (Standard)
- Casing Pipe Nx Size
- Barrel
- Diamond / TC bits Nx
- Core Boxes
- Undisturbed Sampling Tube
- Split Spoon Samplers
- Drop weight

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GEOTECHNICAL INVESTIGATION METHODLO GY:

FIELD WORK

BORING IN SOILS

Shell and Auger Boring

Augers shall be of helical or post hole type and may be manually or power operated. The diameter of hole shall be 150 mm.

Uncased boreholes shall be permitted only upto a depth where sides of the borehole can stand unsupported. In case side fall is noticed, steps shall be taken immediately to stabilize the borehoIe by using casing pipes. While boring through cohesion less soil below water table, water in the casing shall be maintained at or above water table. The auger shall be used for soft to stiff clays, shell for very stiff and hard clay and shells or sand pumps for sandy strata attached to sectional boring rods.

In stiff cohesive soil, it may be necessary to soak the borehole before any progress can be made. While boring, care shall be taken to minimize the disturbance to the deposits below the bottom of the borehole. Bentonite solution with water may be used as per prevailing soil conditions to stabilize the boreholes and to recover the soil from the bottom of borehole.

In-situ test (Standard Penetration Tests) shall be conducted and undisturbed samples shall be obtained at specified depths from the borehole. The borehole shall be kept clean and free from foreign matters while conducting these operations.

Water table in the borehole shall be carefully recorded and reported. The water table in the borehole shall be allowed to stabilize after depressing the writer level adequately by bailing. Stability of the borehole sides and bottom shall be ensured at all times.

Bore Holes- Depth

The boring shall be carried out in all types of deposits including boullders or gravelly strata and excluding hard rock by any of the method. Boring shall be carried out to a depth of 30.0 m or refusal whichever is earlier. In order to confirm existence of rock minimum depth of 3.0 m to be drilled in the rock stratum.

Drilling Exploratory Holes in Rock

Providing all drilling equipment and carrying out NX size core drilling using a single/double tube core barrel.

The work shall comply with IS 1892. The format given in IS code shall be used for recording the rock-drilling, color of wash water, nature of sediments in the wash water, loss or gain of drilling water, core run length, core recovery & RQD (Rock Quality Designation).

Cores shall be kept in wooden boxes is with compartments of exact size of the rock cores.

While placing the core samples in wooden boxes, it shall be ensured that the dir ection and sequence of core placement is not altered. The core run shall be restr icted to the length generally not more than 1.5m. ln weak and friable rock core run shall be reduced.

Core Box

Each core box shall house samples not more than 6m (six meters) long. The depth of cores below ground level shall be indicated at about every 1.5 meters interval by writing the depth in indelible ink on wooden spaces, which shall be inserted in their correct position in the box. Similarly the exact depth of any change in stratum, and failure to recover the core, etc. shall be recorded.

The labeling of core samples of rock shall be done in accordance with Appendix D of IS 1892.

Field Tests

Standard Penetration Test

These tests shall be conducted in all types of deposits and layers at intervals as specified.

The test shall be performed on undisturbed soil by driving of the split spoon sampler by menus of 63.50 kg weight with 75 cm free fall. The number of blows required to affect each 15 cm of penetration shall be recorded. First 15 cm drive to be considered as seating drive. The penetration resistance shall be for the last 30 cm of penetration. The procedure of standard penetration test shall be as per IS: 2131. These tests shall be carried out at interval of 1.50 m within continuous stratum or at every change of stratum whichever is less. The tests shall be terminated at SPT value of greater than 50 or after reaching minimum borehole depth as defined above, whichever occurs earlier, subject to refusal not occurring. The samples obtained in the split spoon sampler shall he Iabeled and preserved for identification tests in the laboratory.

Samplings

Procedure for Sampling

Before sampling operation the bottom of the borehole will be carefully cleaned and every care will be taken to avoid any disturbance of material to be sampled. The following steps will be adopted to collect samples.

For sampling the sampler will be lowered slowly to the bottom of the borehole with the help of drill rods.

The sampling tubes will be driven into the soil by continuous and rapid action, SPT driving equipment will be used for driving the tubes.

ln no case the sampler will be driven further than the length provided for the sample and it will never be driven to full length of the sample tube.

Before pulling out the tube at least 5 Min will be allowed to escape after driving the tube after which the tube will be turned at least for two revolutions to shear the sample at the bottom.

The sample will then be withdrawn smoothly so as to cause minimum disturbance to the samples.

Upon removal of the sampling tube the total length of the sample in the tube and the length between the top of the tube and the top of the sample in tube will be measured and recorded.

The choice of sampling tools, the methods of sampling and the procedure for taking samples shall be in accordance with equivalent IS 1892 recommendations.

Disturbed Soil Samples

Disturbed samples shall be carefully preserved for mechanical analysis and tests.

Undisturbed Soil Samples

Samples for recovering the undistubed soil samples shall conform to IS 2132. The UDS shall be collected at 3.0 m intervals using thin walled 100 mm diameter and 450 mm long open end seamless sampling tube. The tubes shall be driven into the strata at every 3.0 m intervals. On collection of these samples the loose material shall be removed and waxed on either side of the tube. These tubes are properly labeled with depth and Borehole No. The sampling procedure shall conform to IS 1892 and IS 2132.

In very soft or soft clays a priston sampler of an approved design shall be used.

Representative Samples

These Disturbed samples shall be collected at 1.50 m intervals or significant change of strata whichever is earlier. The sample shall be collected from the split spoon sampler used for conducting standard penetration test.

These samples shall be adequately sealed in polythene bags and each sample shall be properly labeled with depth and borehole no.

Soil Samples — Extent

Disturbed and undisturbed soil samples shall be collected from bore holes at every change iii a stratum and at intervals not exceeding 1.5 m and 3.0 m intervals respectively within a continuous stratum. Theses samples shall be preserved and carefully transported to the laboratory for testing.

SEALING AND LABELLING OF SAMPLES

Immediately after taking an undisturbed sample in a tube, the adopter hand will be removed along with the disturbed material. The visible ends of the sample shall each be trimmed off any wet disturbed soil. The ends will then be coated alternatively with four layer of just molted wax. More molted wax will then be added to give a total thickness of not less than 25 mm. All samples will be clearIy labeled including job no. borehole no., sample no., date of sampling, type of sample, depth of sample etc. in case of undisturbed samples (tubes) will be labeled at top.

Ground Water Samples

At the specified depth ground water shall be bailed out so that fresh ground water flows into borehole. Care shall be taken in avoiding any contamination with surface water or bentonite mud. Water samples shall be collected in five liters polythene or glass container, labelled , preserved and sent to the laboratory for chemical analysis.

TRANSPORTING AND STORING OF SAMPLE

All samples will be stored properly at site till they are transported to the laboratory for testing. Sample tubes containing undisturbed samples will not be exposed to direct sun and will be kept in a shade covered with wet gunny bags. These tubes to be transported with taking full care to avoid the chances of distur bance.

LABORATORY TESTS

Necessary laboratory tests shall be conducted on selected disturbed and undisturbed samples in consultation with the Engineer -incharge.

STANDARDS AND PROCEDURES FOR TESTING

Laboratory tests will be carried out accordance with the procedures described in the relevant IS codes of practiced.

ACCESS TO LABORATORY

The client will have right of access to laboratory where tests will have been arranged to be carried out, during the progress of this investigation.

STANDARDS AND PROCEDURES FOR TESTING

Laboratory tests will be carried out in accordance with the procedures described in the relevant IS codes of practiced. These tests shall be carried out to arrive at soil foundation system design parameters and to identify soil and ground water characteristics. The relevant tests shall be carried out to determine the following:

Shear strength, angle of internal friction, cohesion.

Unconfined compression test.

Natural moisture content of each strata

Density of each strata, void ratio

Atterberg limits of each strata

Classification of soils based on grain sizes (sieve analysis and hydrometer analysis)

Consolidation test on cohesive soil.

Triaxial test (drained and undrained) on cohesive soils or Direct shear test on samples of non cohesive soil remoulded at field dry density and field moisture content.

Rock compression Test, Point Load Index, Water absorption, Dry Density

All tests shall be performed as per relevant BIS Codes and as per the directions of the Engineer-incharge. The results of the Laboratory tests shall be submitted in the standard format.

REPORTS

Field Reports

A separate fieldwork report shall be issued for each location. Each report shall contain preliminary data on,

Character and genesis of soil and local geology.

Plot plan indicating locations and reduced levels in boreholes.

Borehole logs.

Description of rock cores including degree of weathering.

Record of Ground water level.

Results of standard penetration tests.

Interim Report

An interim report shall be issued for each location within 10 days of completing field tests and shall

contain,

Results & interpretation of laboratory tests.

Finalized borehole logs including soil and rock classifications.

Results & interpretation of field tests

Cross section/ subsurface profile through boreholes located in a line.

Recommendations of ultimate and safe bearing pressure for foundation and settlement of foundations.

The report shall contain detailed calculations for SBC (Safe bearing capacity) as per IS 6403 for different depths/ strata encountered and corresponding settlements as per IS 8009 (part I) for widths of footing as indicated above. Permissible settlements shall be as per IS 1904.

If open foundations are not feasible, recommendations for pile capacities for a particular- size. Note on chemical attack due to ground water and soil on underground concrete structures and recommendations thereby for the precautions and safety measures to be considered.

All results shall be properly tabulated giving reduced levels of ground and boreholes at various borehole locations, depth of ground water table

The conclusive recommendations shall be given based on test results and field observations keeping in view the local practices in design and construction of soil foundation system.

Final Report

The final report shall incorporate all locations and include the data from field and laboratory including interim reports. Engineering recommendations shall be finalized. The report shall be issued within 6 days of receiving comments on the interim reports.

RISK INVOLVED:

a. Working with mechanical winch and tripods.
b. Interference or presence of unauthorized person inside the area during work.
c. Movement of Traffic.

SAFETY PRECAUTIONS:

a. Area for testing should be properly barricaded.
b. Unauthorized / outside persons will not be allowed to enter inside/near the test assembly and at the time of test.
c. All the workers will be provided with necessary safety equipments.

METHODOLOGY FOR INITIAL PILE LOAD TEST

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INTRODUCTION

This method statement covers the methodology of initial pile load test on 1000/1200 mm diameter pile with reaction piles for design load of 400/500 MT and the test load of 1000/1250 MT respectively.

Test arrangement will be cater for additional 25% above test load.

Diameter of pile (mm)	Design Load (MT)	Test Load (MT)	Test arrangement cater for (MT)
1000	400	1000	1250
1200	500	1250	1562.5

PURPOSE

The purpose of this methodology is to describe the construction procedure to be followed at the site and is in the line of technical specifications of contract.

MAJOR EQUIPMENT

Following equipments / accessories shall be used for conducting load test:

1. Reaction girder assembly — complete set 1 No
2. 600 MT Capacity Hydraulic Jacks 4 No
3. Hydraulic Pump / Power Pack 1 No
4. Calibrated Pressure Gauge 1 No
5. 0.01 mm least count Calibrated Dial Gauge 3 Nos
6. Rigid Datum Bars 2 Nos
7. Tata P & H 320 Crane 1 No

BRIEF METHOD OF CONSTRUCTION

It is proposed to conduct initial pile load test to establish working load or design load capacity of pile. After finalization of the location of both test pile & reaction piles, the same shall be constructed as per method statement. Pile load test will be conducted on a

separately constructed non-working pile of 1000/1200mm diameter bored cast in situ pile. Test arrangement will be done as per static load test method. The test should be carried out by applying a series of vertical downward incremental load, each increment being about 20 percent of safe load on pile. Settlement shall be recorded with minimum 3 dial gauges of 0.01 mm least count and held by datum bars resting on immovable supports at a distance of 3D (subject to min of 1.5 m) from the edge of the pile, where D is pile diameter.

JOB BREAK DOWN

Survey

After finalization of the location and cut off level by client for test pile, survey will be done and pile location will be marked accurately.

Pile boring and casting

Test pile and reaction piles will be constructed as per the method statement for the cast in situ piles.

Test arrangements

1 The center line shall be marked on the top of the test pile accurately.

2 The Fabricated grillage assembly will be erected over the pile based on the marked center line.

3 Specially designed 2 reaction girder along with top grillage assembly will be erected at the test location as per drawings. Reinforcement bars of reaction pile will be suitably connected to reaction girders by Casting anchor block over the top reaction girder as per details indicated in load test Design drawing.

4 The hydraulic jack of 4 nos each 600T capacity will be kept in between grillage assemblies symmetrically.

5 These Hydraulic jacks will be connected with suitable manifolds to hydraulic pump or power pack. Hydraulic pump or power pack will be placed sufficiently away from the test pile.

6 The dial gauge will be fixed to as datum bar whose ends rest upon firm support. Care should be exercised to ensure that the datum bar supports are not affected by heaving up of the soil. The support will be at least 3D away from the pile where D is the diameter of the pile. Three dial gauges will be attached to datum bars with the help of magnetic base. These dial gauges will be placed symmetrically.

7 Hydraulic pumps will be connected to hydraulic jacks and functioning of hydraulic pump/jacks will be checked before commencement of test.

Test sequence

The static load test shall be carried on the initial test piles constructed as per the working methods to be adopted for the regular piling works to find out separately skin friction and point bearing load on single piIe of uniform diameter. The following will be ensured:

- Normally the Test would be conducted on Piles which are at least 28 days old, unless there are special circumstances, for which Engineer may grant prior permission.
- Engineer will be given a Notice of at least 48 hours before the Test.
- Before the Test, all particulars regarding the Test pile including bore data and cube strengths will be kept ready and will form part of the Report.
- The Tests will be conducted in the presence of experienced personnel conversant with the Equipment and Testing procedure.
- All Equipment will be checked at least Two days before and defects noted, if any rectified.

The procedure for the static load test is where the load applied in increment of 20% of the design load up to the failure or 2.5 times the design load, whichever occurs first.

Loading shall be carried out at each stage by applying a series of vertical downward incremental load and each increment being of about 20 percent of design load on the pile. Each loading shall be maintained as per the criterion given below:

1. Dial gauge reading taken at 30 minutes interval & maintaining minimum for 30 minutes during loading.

- Change of load should proceed only if the settlement of the pile is not more thau 0.1 mm in first thirty minutes or 0.2 mm in first 1 hour or till 2 hours whichever occurs first. (Stated in IS 2911)
- Reading was recorded before and after applying increment load.
- The reading of the three dial gauges installed at the reaction pile also recorded in the similar manner.

Result

From the readings of 3 dial gauges, average settlement under each increment of load will be calculated. From results of average settlements, graph of applied time load versus settlement will be plotted along with Pile data.

Total Settlement, Net Settlement and Elastic Rebound of pile will be worked out. The following information will be included in the Test report:

2. Description of soil conditions, ground water table, actual boring and installation Records, concrete cube Test results.

- Method of Load application.

Load settlement readings during Loading- As load test is static

- Time Load settlement curve.
- Any other observation relevant to the test being conducted.

RISK INVOLVED

a. Interference or presence of unauthorized person inside the area during work.

b. Swing of crane boom during erection of heavy structural steel girders.

c. Sudden increase in application of Load.

d. Failure of Jacks.

e. Failure of Structural steel girders.

SAFETY PROCEDURE

f. The area for pile load test will be temporarily barricaded.

g. Unauthorized / outside persons will not be allowed to enter inside/near the test assembly during the erection of girders and at the time of test.

h. All the workers will be equipped with necessary safety equipments.

i. Ensure proper movement of cranes during piling and erection of heavy structural steel girders.

j. The crane swing zone will be always ensured free from the personnel and other objects.

k. All lifting Equipment like cranes and structural steel members etc. will be checked from safety point of view at least one day before the Test and cleared by Safety Engineer.

l. Safety personnel will be present throughout the period of test to prevent any lapse in Safety.

Drawing and photos showing general arrangement for pile load test

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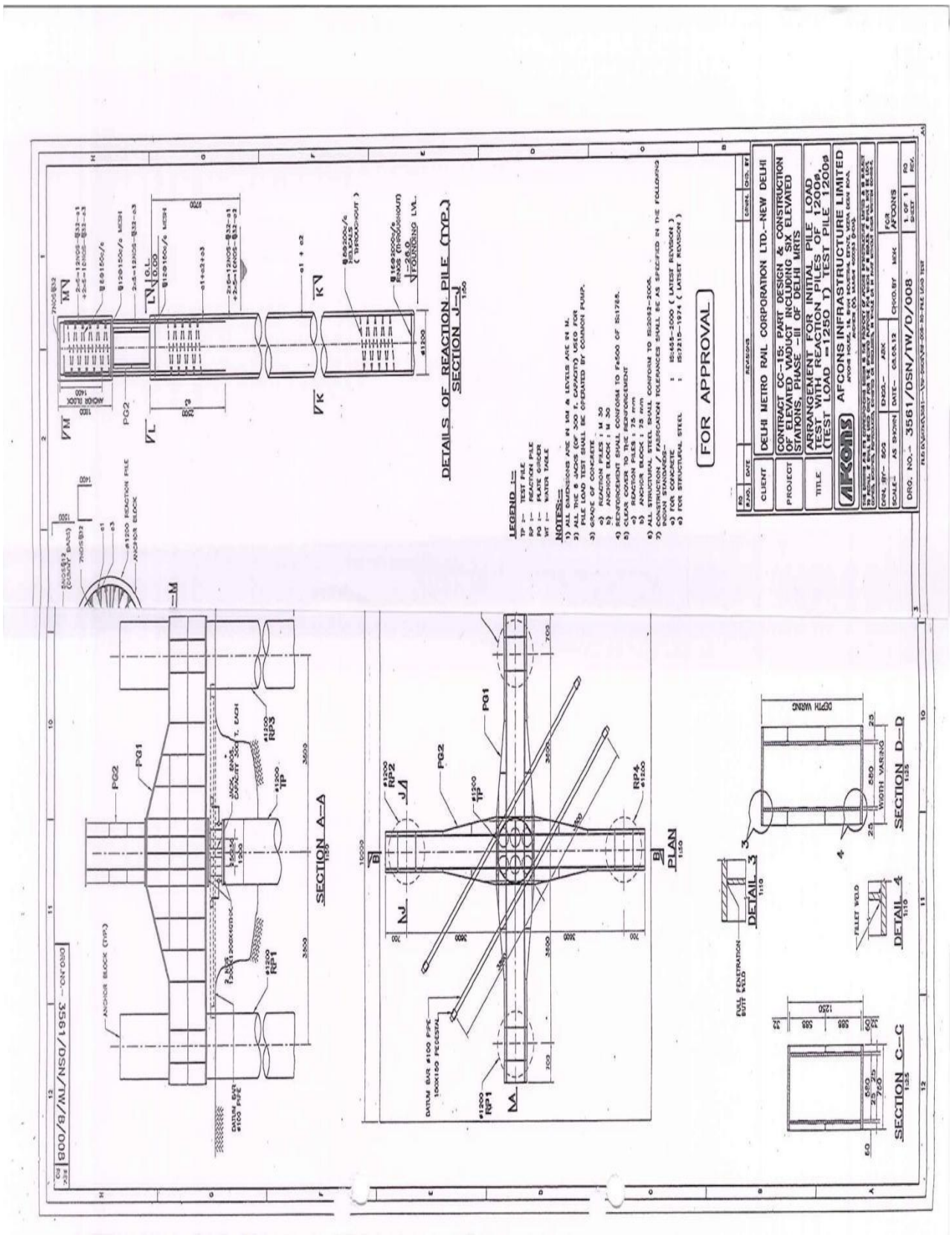

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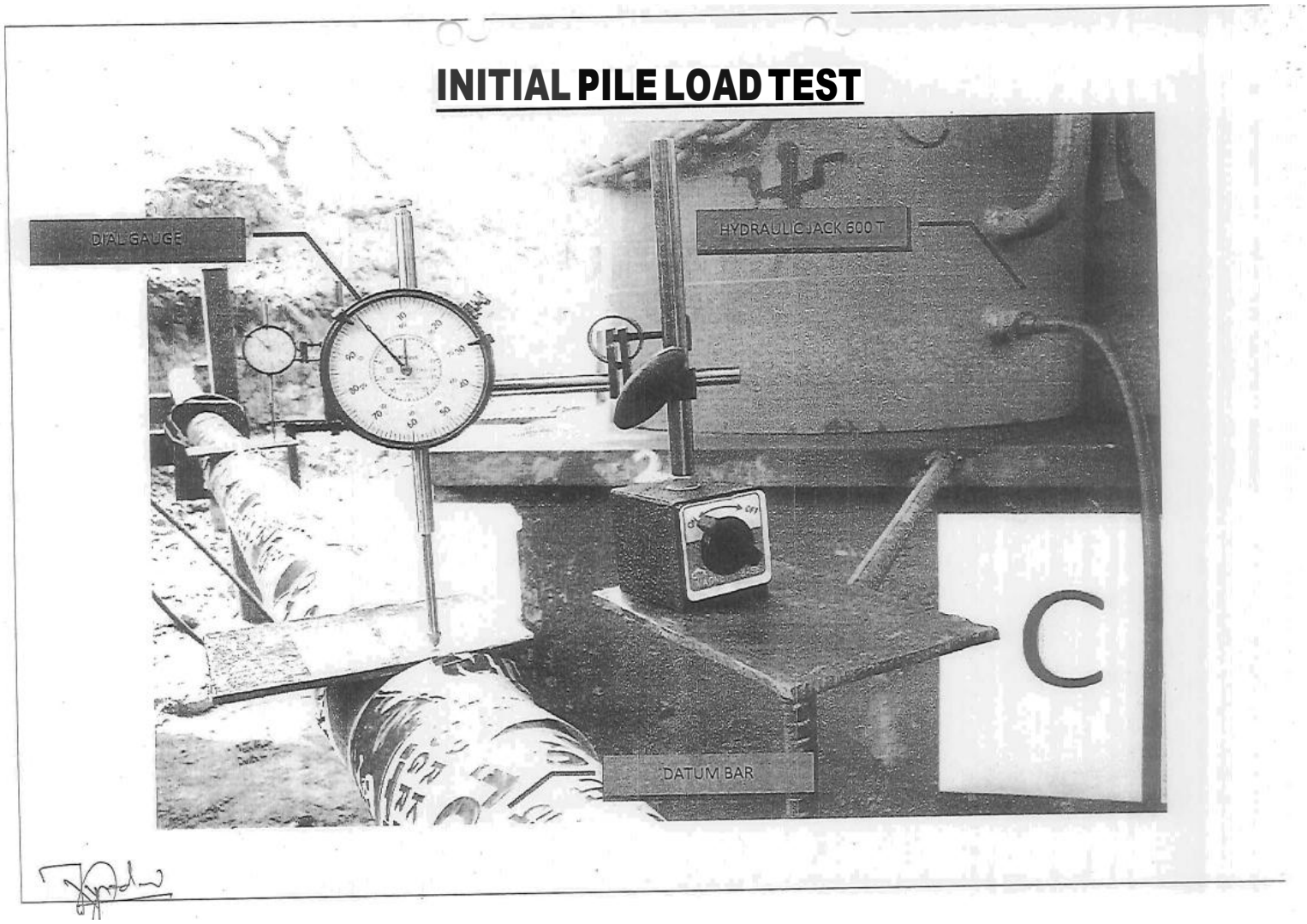

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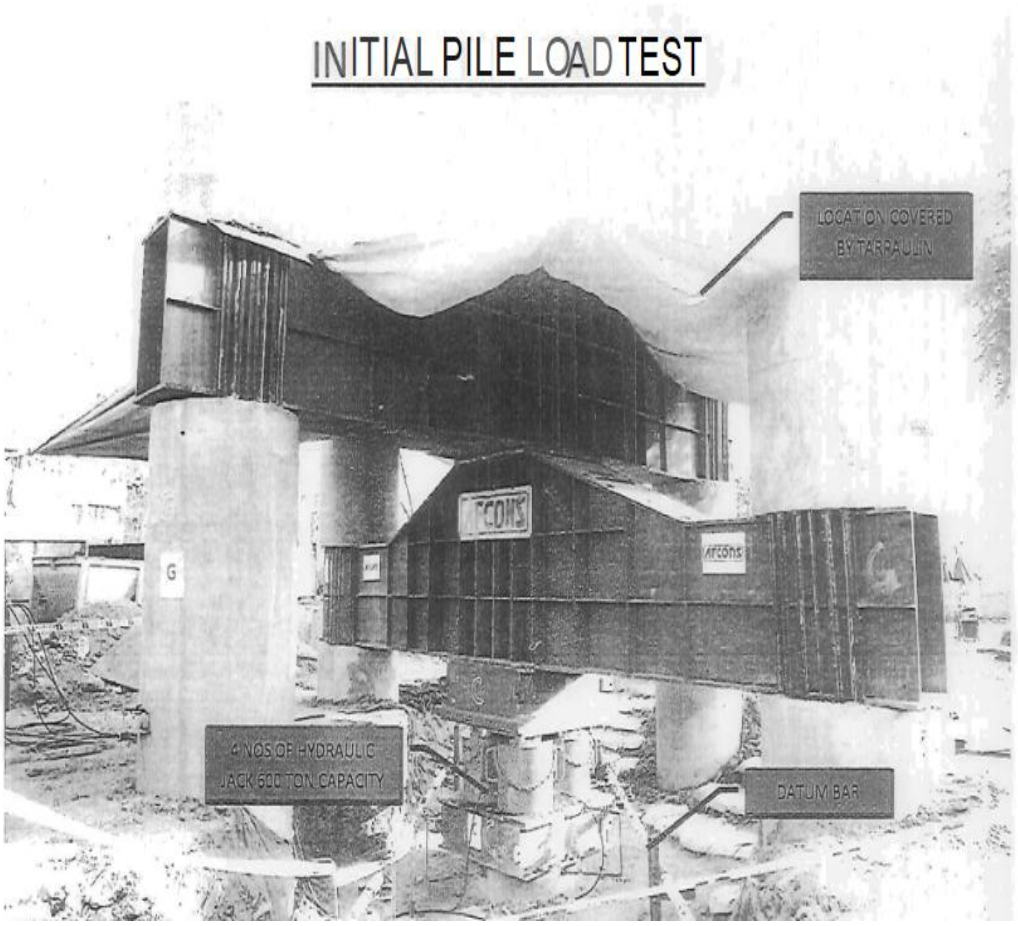

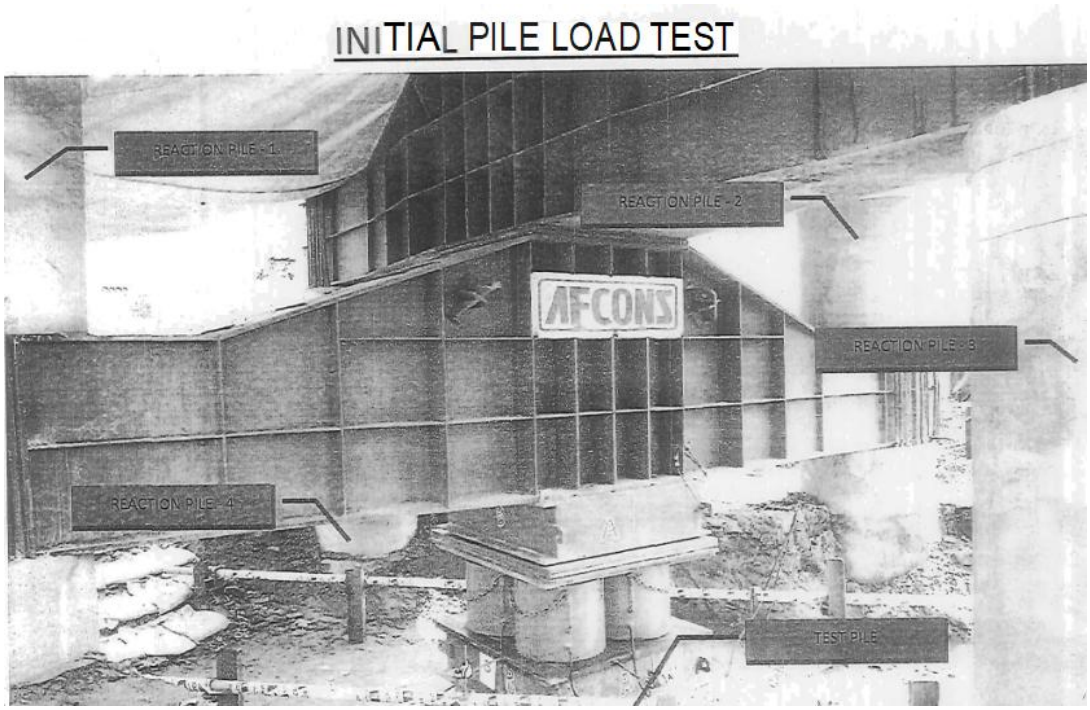

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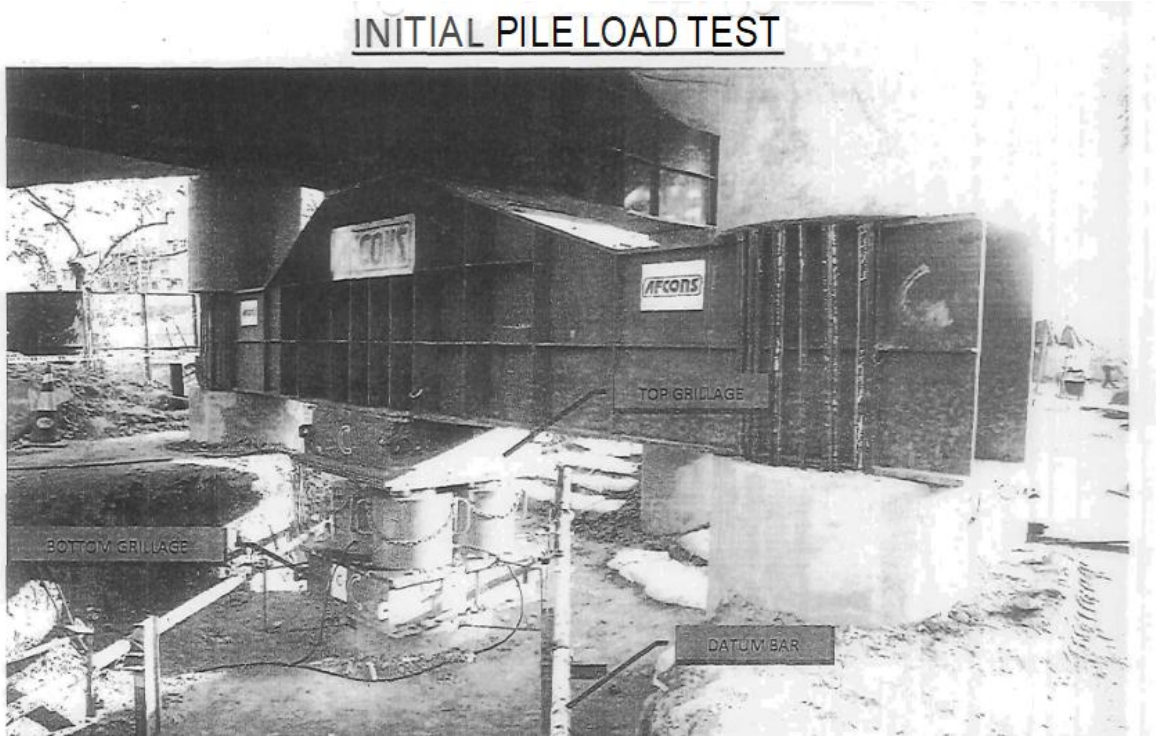

METHODOLOG FOR PRESTRESSING AND GROUTING OF POST TENSIONED SEGMENT GIRDER SPANS

PRESTRESSING MATERIALS

High Tensile Strands

Following are the properties of 15.2 mm dia Low Relaxation High Tensile Strands class II strand shall be used

- Nominal area of Stand 140.0 mm2
- Minimum Breaking Strength 260.7 KN
- Nominal Weight of Strand 1.102 Kg/mtr

SHEATHING PIPES

107 MM ID HDPE Corrugated Duct Having 2.3mm thick +- 0.3mm for 19DP15 Anchorages System.

84 mm ID HDPE Corrugated Duct Having 2.3mm thick +- 0.3min for 12DPI5 Anchorages System

75 mm ID HDPE Corrugated Duct Having 2.3min thick +- 0.3mm for 7DP15 Anchorages System

Dynamic 19DP15 I 12DP15 / 7DP15 Live end Anchorage System

Tube Unit (Anchor Cone)

The basic raw material for manufacture of tube unit is gray cast iron. It allows the transfer of pre stressing force from the bearing plate to the concrete. The Tube Unit is embedded in concrete and can be easily fixed to the MS cone box by means of bolts and nuts. The design of Tube Unit allows uniform flaring of H.T. Strands while stressing and free access to the injection of grout.

*Anchor Head (Bearing Plate)

The basic raw material for manufacture of bearing plate is Steel casting / forged steel. The conical holes facilitate the seating of wedges and holding the strands in stressed condition.

* Wedges

The basic raw material for manufacture of wedges is alloy steel. The individual high tensile strands passing through the bearing plate is anchored by the wedges. The 3 segments of the wedges are held together around the strand by means of special wire clips for better functioning, easy placement and storage

Prestressing and Grouting is broadly divided into following activities, viz.,

- Layout & Profiling of the cables/sheathing.
- Fixing of tube unit/end block.
- Cable cutting and threading.
- Fixing of Bearing plate & Wedges.
- Stressing.
- Cutting and end Sealing.
- Grouting.

LAYOUT & PROFILING OF SHEATHING PIPES

After completion of alignment of bottom shuttering & bottom reinforcement of girder, layout & Profiling of cables shall be carried out in following steps :

Layout of cables is carried out as per given ordinates & related reference drawings. After all ordinates are plotted, tie bars of 10 mm dia. shall be installed as per ordinates to place the sheathing pipe wherever required. Installation of sheathing pipe is carried out over the tie rods.

Sheathing pipe shall be supported in the bottom by tie rods & shall be cross bound using double binding wire. lt should be ensured that the sheathing pipes are fixed firmly in position so as to prevent displacement during concreting by weight of concrete, vibration or by floatation.

Connect the sheathing with the help of couplers provided at the end of each pipe. Sealing of sheathing joints will be done using PVC tapes. It will be ensured that no joints are remaining unsealed.

Cable profile shall be checked. Vertical ordinates shall be check from soffit of the bottom shutters. Horizontal ordinates shall be check from the face of the side shutters, which has been already checked for verticality or as in drawing.

FIXING OF TUBE UNIT

Fixing of tube unit shall be carried out after installation of end shuttering plate.

Fix tube unit to End plate with the help of 4 nos. of bolts.

Bursting reinforcement shall be fixed according to the drawing.

Connecting the tube unit to sheathing pipe.

Joint shall be sealed with the help of PVC tape.

The face of the tube unit shall be truly perpendicular to the axis of the cable and about 1.5m of cable before trumpet should be in straight alignment.

After the fixing of tube unit and cable layout, insert the HDPE pipes Or HTS Strand inside all ducts to avoid the damage of sheathing pipe & ingress of cement slurry inside the duct at the time of concreting.

CONCRETING

Although concreting is not a part of stressing, but it plays a vital role in successful stressing of structure.

It shall be noted that the needle vibrator is not placed directly on sheathing pipe, which may damage the sheathing pipe.

HDPE pipe or HTS Strands in all the cables should be moved in both directions during the period of concreting.

Due care should be taken while concreting in the end block portion. Proper compaction of concrete should be ensured to avoid honeycombing.

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CABLE CUTTING & THREADING

After completion of concreting & removing end block shUttering, cable threading shall be done.

H. T. Strands shall be threaded manually.

For cutting strands, a portable grinding wheel shall be used.

H. T. Strands shall be cut as given in drawings, considering site conditions & gripping length of jack.

The cut H.T strands will be placed on plastic sheet to avoid contamination. If it is contaminated accidentally the HT strand shall be wiped off with petrol.

FIXING OF BEARING PEATES & WEDGES

Fixing of bearings plates & wedges is done before stressing. It is ensured that the tapered holes in bearing plates & wedges are free of rust.

Insert the strands into the tapered holes provided in the bearing plate.

Install the wedges over the strands and push them with a pipe into the tapered holes of the bearing plate.

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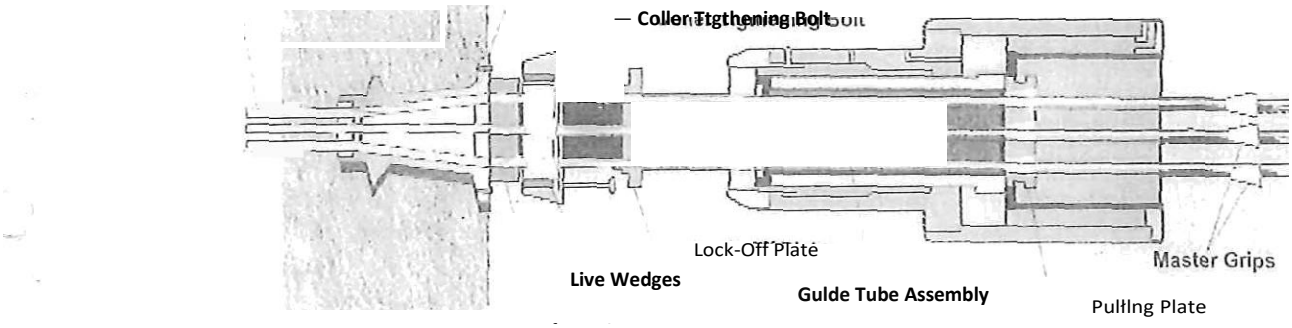
STRESSING

Tube Unit Pre stressing Jack

Bearing Coller

—Sheath Pipe



Prestressing of the girder is done as required by the system of prestressing and design. Following points will be observed while carrying out the stressing operation.

The required characteristic strength of the girder concrete as mentioned in drawings/specifications shall be ensured by cube testing before starting the stressing work

Stressing of cables shall be done as per the sequence mentioned in the drawings/specifications.

Elongation mentioned in the drawings must be modified for actual value of modulus of elasticity 'E' and the area of c/s of strands 'A' of the cables as per taken from MTC for the particular coil unless otherwise mentioned in the drawings/specifications.

Actual pressure shall be calculated after applying Jack efficiency factor.

Stressing shall be done using Multi-pull jacks only.

Stressing shall be done from one ends or both ends as mentioned in the drawing, care will be taken to achieve almost equal readings of elongation at both the ends in each step of increment of pressure.

Readings will be taken preferably at incremental steps of 50 kg/cm2 up to the final pressure.

Where the anticipated elongation of cable is beyond the maximum extension of the jack-ram, the

stressing operation shall be done in two or more bits. Elongation shall be calculated for individual bites and summed to arrive at the total value.

Strands of the cable shall be monitored by both jack force and through actual elongation. Based on the actual values of c/s area and E-value of the pre stressing strand, corrections shall be applied to the theoretical elongation given in the stressing schedule in order to obtain the true theoretical elongation.

After locking the wedges the pressure in the jack will be released very slowly to avoid transfer of pre stressing force by impact.

In every cable instantaneous slip of anchorages must be recorded. It will be within limits prescribed by the designer or by the pre stressing agency.

The pressure applied and elongation achieved will match within the prescribed limits. Normally, this limit is 5% of pressure and elongations.

No person will be allowed to stand behind the anchorages in any circumstances during the process of tensioning.

THE FOLLOWING STEPS SHOULD BE PREFERED FOR JACK MOUNTING:

Fix the bearing plates at both the ends of the tensions.

Insert the bearing collar & fix it on tube unit with the help of screws. Insert the lock-off plate as per the orientation the bearing plate.

A rigid runaway beam (ISMC/ISMB) structure shall be made at the end of the bridge girder from where the Jack is to be suspended by means of a chain pulley block. The arrangement will give full flexibility of movement of Jack both transversely and longitudinally.

Push the Jack over the strands. The axis of the Jack must coincide with the tendon axis. Insert the strand into the Jack.

Apply “wax” inside the holes of pulling plate as well as outside of master grip.

Install the 3-piece wedge (master grip) over the strand into the pulling plate inside the rear of the Jack. Push the grips with a piece of hollow hammering pipe to seat tightly inside the pulling plate holes.

Ensure all connection of Jack with pump is correct and flexibility of hose pipe for movement of the Jack at the time of stressing.

It is important that the supporting chain or hook shall be slackened off as soon as the Jack starts to carry load, but they must be ready to support the Jack again when the pressure is released. Locking pressure should be maintained approximately 1.5 Ton to 2 Ton per live wedge

Calibration and maintenance

Pressure Gauges

Gauges shall be calibrated either against a master gauge or preferably by a dead weight tester at regular intervals. Calibration of all gauges shall be done at an interval so that satisfying the following conditions:

At least once in every three months

At least once for every 400 stressing operations

In case observed elongations are varying more than 10% from the expected elongations.

At any sign of malfunctioning. All the jacks shall be tested for their efficiencies in all the possible combinations for jack calibration procedure. At least once in every year

CUTTING AND END SEALING

Cutting should be carried out after checking the 24 hrs. slip loss. Slip loss is checked by marking the strand at 100 mm from wedge and measuring the distance between the wedge and marking after 24 hrs. Strand should be cut approximately 40 mm. from the face of bearing plate. End sealing should be done with the help of GROUT CAP or Epoxy & cement Mortar (Mounting the ends).

GROUT CAP:

The advantages of using Dynamic Grout Cap are used for speedy gi'outing atid saving of sealing material i.e. cement mortar.

FIXING OF GROUT CAP

The stressed strands are cut to the required length i.e. 40 mm. from the face of bearing plate.

On the inner surface of cap, grease should be applied.

'O' ring should be placed in the slot provided along the periphery of the cap, which maintains the pressure and prevents the leakage of grout.

Grout cap is fixed by 4 nos. of bolts by keeping the air vent nut in top position.

GROUTING

Neat cement slurry should be filled in the annular spaces between sheathing duct & high tensile (H.T.) steel/strands.

OBJECTIVES OF GROUTING:

To protect the steel against corrosion.

Effective bond between the Pre stressing steel and concrete.

GROUT TEMPERATURE

Generally, the temperature of the grout must be below 25 °C. In summer season the grout temperature will be maintained using ice. lt is likely to change depending upon the site conditions

GROUT TEST

3 nos. samples for each session of operation of size cube 100 mm x 100 mm x 100 mm. Strength of cube should be not be less than 17 MPa on 7^{th} day. .

GROUTING PROCESS

Following points will be observed while doing the grouting.

Grouting of cables shall be done as early as possible, alter completion of stressing.

All cables that are to be grouted shall be cleaned thoroughly with water & compressed.

The grout mix is prepared in the agitator by thoroughly mixing it for 2 to 3 min.

The agitator must be placed at a height such that mortar can flow directly in top second tank placed beneath the outlet of agitator.

Before flowing in to the second tank mortar must be passed through a 2 mm. mesh screen so as to eliminate impurities and lumps which otherwise cause choking of the pump at the time of grouting process.

Connect the suction hose of grout pump to the second drain.

Operate the pump to drain off water from the pump and hoses.

Allow discharge of a small quantity of grout from delivery hoses to check the correct functioning of pump.

Connect the delivery hoses to the tube unit’s grout inlet opening and begin grouting. Ensure that there is always enough grout in tank so that air is not sucked in to the pump. When the grout flows out of the dead

end tube unit's front opening, open the air vent nut of the grout caps of both the ends.

Block the outlet of the other end after being assured that the air has been completely bleeded and the duct is filled with grout.

Close the art vent nut and operate the pump until the desired pressure is achieved.

After the design pressure is achieved, stop the pump and maintain the pressure of 3-5 Kg/cm2 for 1 min. and close the valve of inlet connector.

Release the pressure in hose. The pump runs idle and returns grout to the tank.

Clean the grout pump & agitator with clean water to avoid clogging.

END PROTECTION OF ANCHORAGES

Tendons shall be protected against corrosion by a plug at each end to prevent passage of air. After grouting is over the anchorages will be protected for corrosion as under

Clean the exposed anchorage parts for rust and dirt with wire brush manually.

Clean the surface with cotton waste & apply a coat tar epoxy (solvent free araldite)

SAFETY PRECAUTIONS

Safety Precautions While Concreting

Although concreting is not a part of pre stressing, it plays a vital role in successful stressing of structure. Following points should be considered while concreting

Main contractor should ensure that vibration is to be supervised. It should be noted that needle is not directly placed on sheathing pipe, which may damage the duct & thereby blocking the path of strands.

The portion of the end block of the girder should be properly concreted. Weak concrete leads to puncture of tube unit & hence stressing should be done only if concrete is capable of taking the load.

It should be ensured that the bursting reinforcement in the end block zone is adequately & properly installed.

Safety Precautions While Stressing

Very large forces are introduced into the tendons during stressing and the equipment is under high hydraulic pressure. Hence, careful working can avoid accidents.

Only trained and experienced personnel, under the guidance of Dynamic technical Staff, should perform stressing.

The equipment, especially the high pressure hoses and the adaptors most be in perfect condition. Damaged hoses must be replaced immediately. Protection caps must always be placed over unused connections (electric as well as hydraulic).

Jack should never be handled by hoses.

Stressing should be done according to specified data. The allowed maximum pressure should never be exceeded.

During stressing, nobody should be allowed behind or underneath the jack, since failure of a strand can cause fatal accidents.

For stressing close to traffic areas, the jack must be secured by ropes or chain hoist.

All bars, wires and strands should be stored carefully. Ensure that they are not damaged in any way and should be checked for rust and corrosion before they are used.

Care should be taken while handling coils of high tensile steel strand as they may whip back with force, if not securely bound.

Do not permit welding near' high tensile Pre stressing steel. A drop of molten metal, if applied to the strand, will change its mechanical properties and promote the possibilities of premature failure.

Hogging of the girder during stressing operation should be observed & recorded.

Safety Precautions While Grouting

Protective glasses must be worn during grouting operation.

Do not start the pump while valves are closed, it may cause damage to the pressure gauge.

Place the grout tank preferably at the same level of grout pump.

In case of a longer stoppage (more than 5 min), ensure that the grout does not get set in the pump, if necessary empty the grout and flush the pump with water.

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CONCLUSION:

There is a huge scope for the construction of metro rails in India as it is a second most populous country and foremost developing country in the world. In every work there will be certain amount of risk especially in infrastructure projects there will be more number of risks and uncertainties because of its scope and cost. This study shall involve the unstructured interview method as the construction scope is large which completes the overview of the risk management analysis in the metro rail project .This study shall focus on how the construction industry is taking the care of risk management in infrastructure projects. As every coin has two sides, risk is also having two sides negative and positive. This study shall reveal how the risk management analysis has to be done and how they are affecting the project. The study of Risk management analysis is an on-going research work in order to identify the new strategies to implement effectively in the construction industry especially for the infrastructure projects as the scope and the cost overruns are huge.

Risk management in the construction project management context is a comprehensive and systematic way of identifying, analyzing and responding to risks to achieve the project objectives. To manage the risk effectively and efficiently, the contractor must understand risk responsibilities, risk event conditions, risk preference, and risk management capabilities.

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