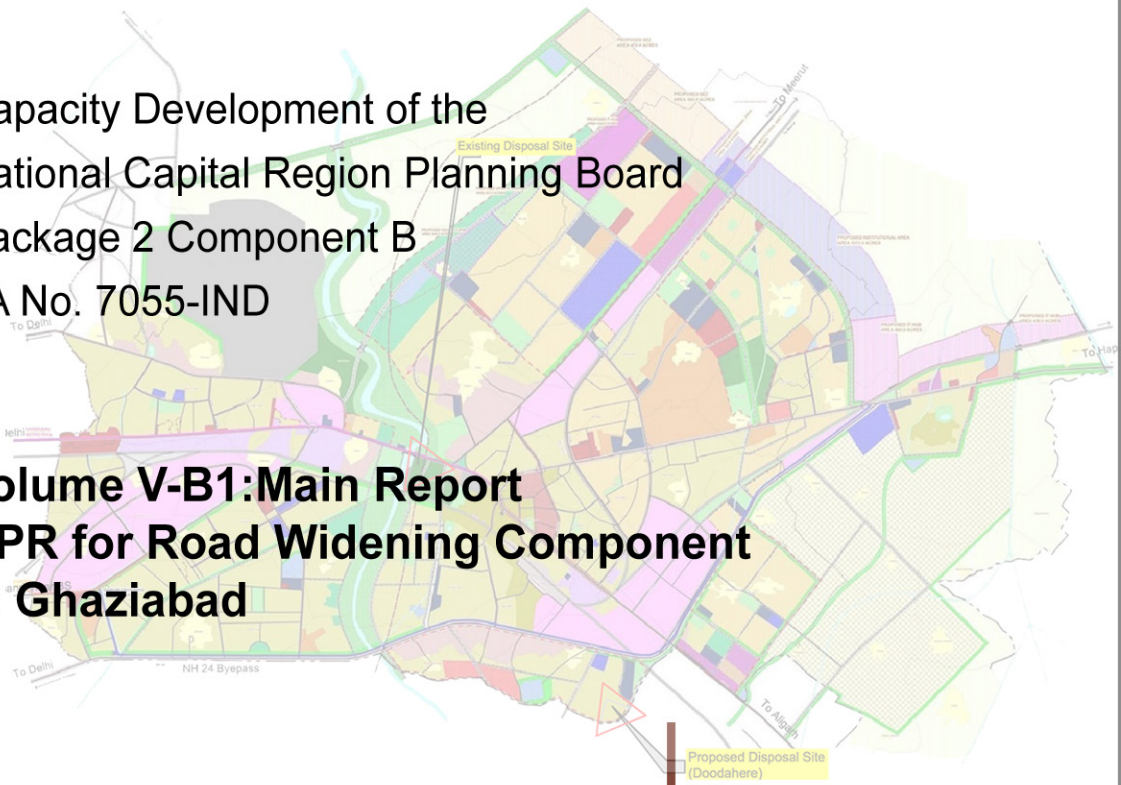
FINAL REPORT

Asian Development Bank

National Capital Region Planning Board

Capacity Development of the
National Capital Region Planning Board
Package 2 Component B
TA No. 7055-IND



Volume V-B1:Main Report
DPR for Road Widening Component in Ghaziabad

WilburSmith ASSOCIATES

July 2010

NCR Planning Board
Asian Development Bank

Capacity Development of the National Capital Region Planning Board (NCRPB) – Component B

(TA No. 7055-IND)

FINAL REPORT

Volume V-B1: DPR for Road Widening Component in Ghaziabad

Main Report

July 2010

Abbreviations

ADB	Asian Development Bank
DFR	Draft Final Report
DPR	Detailed Project Report
FR	Final Report
TA	Technical Assistance
NCR	National Capital Region
NCRPB	National Capital Region Planning Board
NH	National Highway
MORT&H	Ministry of Road Transport and Highways
BIS	Bearue of Indian Standard
IRC	Indian Road Congress
IS	Indian Standard
KMPH	Kilometer per Hour
SP	Standard Procedure
RCC	Reinforced Cement Concrete
CBR	California Bearing Ratio
LCV	Light Commercial Vehicle
MAV	Multi-axle Vehicle
CMSA	Cumulative number of Million Standard Axles
BC	Bitumen Concrete
DL	Deal Load
BOQ	Bill of Quantities
INR	Indian Rupees

Contents

1. INTRODUCTION 1

A. BACKGROUND 1
B. OVERVIEW OF THIS ADB TA 2
C. ABOUT THE FINAL REPORT 3
D. STRUCTURE OF VOLUME V REPORT 4
1. Structure of this Volume V-B Report 4

2. TRAFFIC SCENARIO 5

A. TRAFFIC SCENARIO ON NH-91 IN GHAZIABAD 5

3. ENGINEERING SURVEYS & INVESTIGATIONS 7

A. GENERAL 7
B. TOPOGRAPHICAL SURVEYS 7
1. Detailed Survey of Topographical Features 7
C. TRIAL PIT/ SUBSOIL INVESTIGATIONS 8
1. For Pavement Design 8
2. Soil Testing for Embankments 11
D. MATERIAL SURVEY AND ANALYSIS 11
1. Bitumen 11
2. Water Quality 12
E. IDENTIFICATION OF UTILITIES 12

4. EXISTING FEATURES, IMPROVEMENT PROPOSALS & DESIGN STANDARDS 13

A. GENERAL 13
B. PROJECT ROAD 13
1. Terrain and Landuse 14
2. Existing Carriageway and Pavement Details 14
3. Right of Way 15
4. Existing Horizontal and Vertical Geometry 16
5. ROB Along Project Stretch 16
6. Intersections and Junctions 16
C. NEED FOR IMPROVEMENT AND PROPOSAL 17
1. Geometric Improvements 19
D. DESIGN STANDARDS 19
1. Geometric Standards 19
2. Design Speed 20
3. Carriageway Width 20
4. Camber 20
E. DESIGN OF PAVEMENT 21
F. JUNCTION IMPROVEMENTS 22
G. DRAINS 22
H. LIGHTINGS 22
I. ROAD FURNITURE - ROAD SIGNAGE AND MARKINGS 22
J. UTILITY RELOCATION 23

5. BILL OF QUANTITIES COST ESTIMATES 24

A. BILL OF QUANTITIES 24
B. RATE ANALYSIS 24
C. ESTIMATED COSTS 24

List of Tables

Table 2-1: Details of existing utilities 6
Table 3-1: Laboratory Test Results for Sub grade Area Soil 10

Table 3-2: Details of Existing Utilities....12
Table 4-1: Details of Lane Configuration....15
Table 4-2: Details of ROW Available at Site....15
Table 4-3: Intersections along the Project Road....16
Table 4-4: Junctions along Project Road....17
Table 4-5: Geometric Design Standards....20
Table 4-6: Flexible Pavement Compositions....22
Table 4-7: Proposed Road Furniture along the Project Road....23
Table 5-1: Summary of Cost Estimates....25

List of Figures

Figure 2-1: Peak Hour Journey Speed on Major Roads in Ghaziabad....5
Figure 2-2: Cordon Count Projection at NH-91....6
Figure 2-3: Typical 6-lane Carriageway Cross Section....6
Figure 4-1: Location of Project Road....14
Figure 4-2: Condition of Payment....15
Figure 4-3: Typical Six Lane Carriageway Cross Section....18

List of Appendices

Appendix 1: Soil Investigation Report

Compendium Volumes

Besides this Volume V-B1, the DPR for Widening of NH-91 in Ghaziabad has following Volumes appended separately.

Volume V-B2: Detailed Drawings
Volume V-B3: Detailed Estimates
Volume V-B4: Financial & Economic Analysis
Volume V-B5: Initial Environmental Examination
Volume V-B6: Short Resettlement Plan

1. INTRODUCTION

A. Background

1. The National Capital Region Planning Board, constituted in 1985 under the provisions of NCRPB Act, 1985, is a statutory body functioning under the Ministry of Urban Development, Government of India. NCRPB has a mandate to systematically develop the National Capital Region (NCR) of India. It is one of the functions of the Board to arrange and oversee the financing of selected development projects in the NCR through Central and State Plan funds and other sources of revenue.

2. On Government of India's request, Asian Development Bank (ADB) has formulated the technical assistance (TA) to enhance the capacities of National Capital Region Planning Board and its associated implementing agencies. The TA has been designed in three components: Component A relates to improving the business processes in NCRPB; Component B relates to improving the capacity of the implementing agencies in project identification, feasibility studies and preparing detailed engineering design; and Component C relates to urban planning and other activities.

3. ADB has appointed M/s Wilbur Smith Associates to perform consultancy services envisaged under Component B. In the context of this contract, the first deliverable – Inception Report, was submitted in October 2008. The second deliverable –Interim Report comprising Master Plan for sewerage in Hapur, Master Plan for Water Supply for Panipat, Master Plan for Drainage for Hapur, Master Plan for Solid Waste management for Ghaziabad, Traffic and Transport analysis for Ghaziabad, Socio-Economic base line survey result in 3 sample project towns and proceedings of workshop 1 was submitted in January 2009. The four Master Plans as stated above are also made available on NCRPB web site for use of the implementing agencies.

4. The third deliverable Draft Final Report (DFR) comprising Detailed Project Report (DPR) for water supply in Panipat, DPR for sewerage in Hapur, DPR for drainage in Hapur, DPR for drainage in Sonipat, DPR for solid waste management in Ghaziabad, DPR for four selected transport components (Flyover, Road widening, Multi-level Parking and Bus Terminal) in Ghaziabad, and a Report on Capacity Building Activities were submitted.

5. Now, this is the Final Report (FR) and is the fourth and final deliverable. The comments/feedback on Draft Final Report received from ADB, NCRPB and respective implementing agencies were duly incorporated and final DPRs for components of Water Supply, Sewerage, Drainage, Solid Waste Management, and Transport are submitted as part of this Final Report. This is the Detailed Project Report for Transport Component of Road Widening in Ghaziabad.

B. Overview of this ADB TA

6. *Objectives*. The objective of this TA is to strengthen the capacity at NCRPB, state-level NCR cells, and other implementing agencies in the area of planning for urban infrastructure and to impart necessary skills to conceive, design, develop, appraise and implement good quality infrastructure projects for planned development of NCR. The increased institutional capacity of the NCRPB and the implementing agencies will lead to effective and time scaling-up of urban infrastructure to (i) improve quality of basic urban services in the NCR; (ii) develop counter magnet towns; (iii) reduce in migration into Delhi and orderly development of NCR; and (iv) accelerate economic growth in the NCR.

7. The TA – Capacity Development of the NCRPB, Component B focuses on strengthening the capacities of NCRPB and implementing agencies relating to project feasibility studies and preparation, and detailed engineering design in the implementing agencies. Specifically, this component B of the TA will support the project preparation efforts of the implementing agencies by preparing demonstration feasibility studies that include all due diligence documentation required for processing of the project in accordance with best practices, including ADB's policies and guidelines.

8. *Scope of Work*. According to the terms of reference of the TA assignment, the following activities are envisaged in component B of the TA:

   (i) Conduct technical, institutional, economic and financial feasibility analysis of identified subprojects in the six sample implementing agencies;
   (ii) Conduct safeguards due diligence on the subprojects, including environmental assessment report and resettlement plan for all subprojects covered in the sample implementing agencies;
   (iii) Prepare environmental assessment framework and resettlement framework; and
   (iv) Develop a capacity building and policy reform program for the implementing agencies, including governance strengthening, institutional development and financial management.

9. Besides, this component of the TA will also:

   (i) help in assessing the current practices and procedures of project identification and preparation of detailed project reports including technical, financial, economic and social safeguard due diligence;
   (ii) support preparation of standard procedure manuals for project identification and preparation of detailed project reports including technical, financial, economic and social safeguard due diligence;
   (iii) train the implementing agencies in the preparation of detailed project reports by using the sample subprojects, reports on deficiency of current practices and standard protocol manuals; and
   (iv) help in developing a user-friendly web-page where different manuals and guidelines for preparation of DPRs will be made available for the implementing agencies.

C. About the Final Report

10. At Interim Report stage of the TA, the Master Plans for Water Supply in Panipat, Sewerage system in Hapur, Drainage for Hapur and Municipal Solid Waste Management for Ghaziabad were prepared. The Master Plans provided 100 percent coverage of population and the area likely to be in planning horizon year 2031/2041. All works required up to planning horizon year were conceptualized, broadly designed and block cost was estimated. The Master Plans also provided phasing of investment such that under phase 1 works required to cover present spread of city were proposed.

11. At draft final report stage of the TA the Detailed Project Reports (DPRs) were prepared for Phase 1 works as suggested in the Master Plans. For preparation of DPRs, engineering surveys and investigations were conducted and various possible and feasible alternatives evaluated. Finally for the selected options the DPRs prepared with detailed designs, item wise detailed cost estimate, work specifications, implementation process and proposed implementation arrangements. Further, according to ADB procedures these DPRs in addition to technical analysis included institutional, financial and economic feasibility analysis and environmental and social safeguards due diligence – environmental assessment and resettlement plans.

12. The DPR's submitted as part of Draft Final Report was reviewed by the implementing agencies, NCRPB and the ADB. Now this Final Report comprising DPR's modified in light of comments of IA's is being submitted. The draft DPR for water supply in Panipat was reviewed by PHED Haryana. Detailed discussions were held with Superintending Engineer (Urban), Executive Engineer (Urban), Superintending Engineer (Karnal) and Executive Engineer Panipat. The comments made by PHED have been suitably incorporated in this Final Report.

13. These DPRs are proposed to be made available to the ULBs and other implementing agencies of the state governments as model DPRs so that they may replicate the methodology/approach in the future DPRs prepared by them for obtaining finances from the NCRPB.

14. *Organization of this Final Report*. The Final Report of the TA Component B is organized in following Seven Volumes:

Volume I: Detailed Project Report for Water Supply System in Panipat

Volume II: Detailed Project Report for Rehabilitation and Augmentation of Sewerage System in Hapur

Volume III: Detailed Project Report for Rehabilitation of Major Drains in Hapur

Volume IV: Detailed Project Report for Improvement of Solid Waste Management System in Ghaziabad

Volume V: Detailed Project Reports for Four Transport Components in Ghaziabad

Volume VI: Capacity Building Activities

Volume VII: Detailed Project Reports Rehabilitation of Drainage in Sonipat

D. Structure of Volume V Report

15. The DPRs for all four transport components are compiled in Volume V. This is Volume V is presented **four** volumes:

(i) **Volume V-A**: DPR for Mohan Nagar Flyover
(ii) **Volume V-B**: DPR for Road Widening
(iii) **Volume V-C**: DPR for Bus Terminal
(iv) **Volume V-D**: DPR for Multi-level Parking

1. Structure of this Volume V-B Report

16. This DPR for Mohan Nagar Flyover in Ghaziabad is compiled in following six sub-volumes (**Volumes V-B1 to V-B6**) including this Main Report:

Volume V-B1: Main Report:

- **Section 1** Introduction
- **Section 2** presents traffic scenario at on the selected stretch on NH 91 in Ghaziabad
- **Section 3** provides details of engineering surveys and investigations carried out
- **Section 4** presents existing road features and details on the proposed improvements and design standards
- **Section 6** presents estimate and costing

Volume V-B2: Detailed Drawings
Volume V-B3: Detailed Estimates
Volume V-B4: Financial & Economic Analysis
Volume V-B5: Initial Environmental Examination
Volume V-B6: Short Resettlement Plan

2. TRAFFIC SCENARIO

A. Traffic Scenario on NH-91 in Ghaziabad

17. National Highway 91, which is also known as the old NH24 is a busy corridor carrying a high volume of traffic. The stretch of the roadway between Hapur Bypass and Y Junction is currently a four-lane divided highway. However, because a number of commercial establishments abut the corridor and one lane is used for parking, the capacity of the roadway is considerably reduced resulting in congestion along the stretch under consideration.

18. The volume counts conducted at three locations along this corridor indicated that the volume capacity ratios are at unacceptable levels (as high as 1.16 near Chowdary Junction) and would further increase in the future years. The junction capacities have exceeded the limits along the corridor. The future volume forecast reveals substantial traffic flow on this corridor.

19. The speed survey carried out on this stretch of the corridor has indicated a low speed of 22 kmph during peak hours.

Figure 2-1: Peak Hour Journey Speed on Major Roads in Ghaziabad

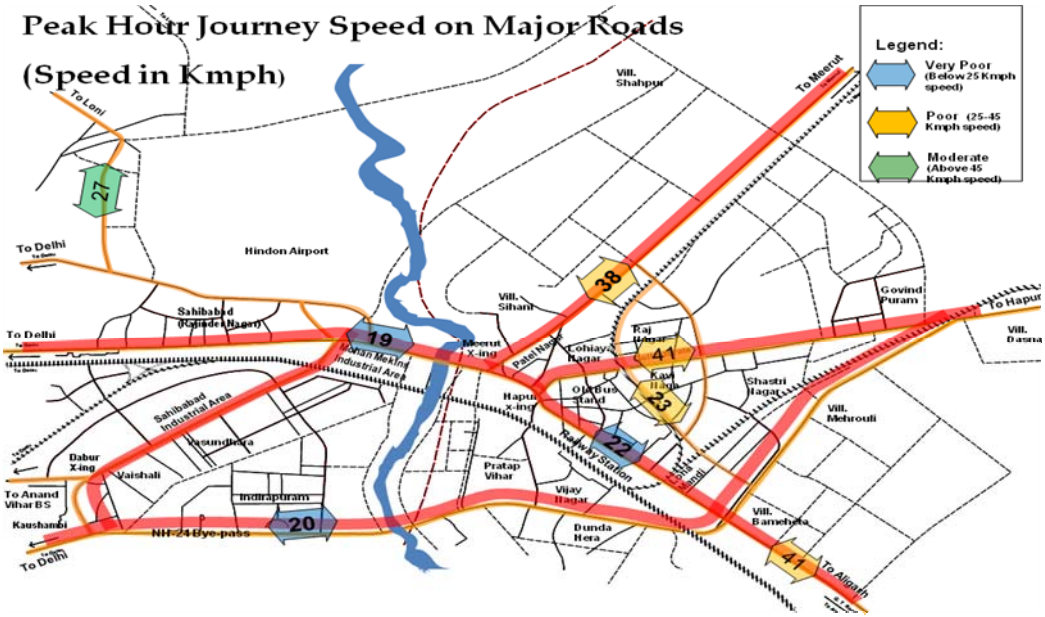
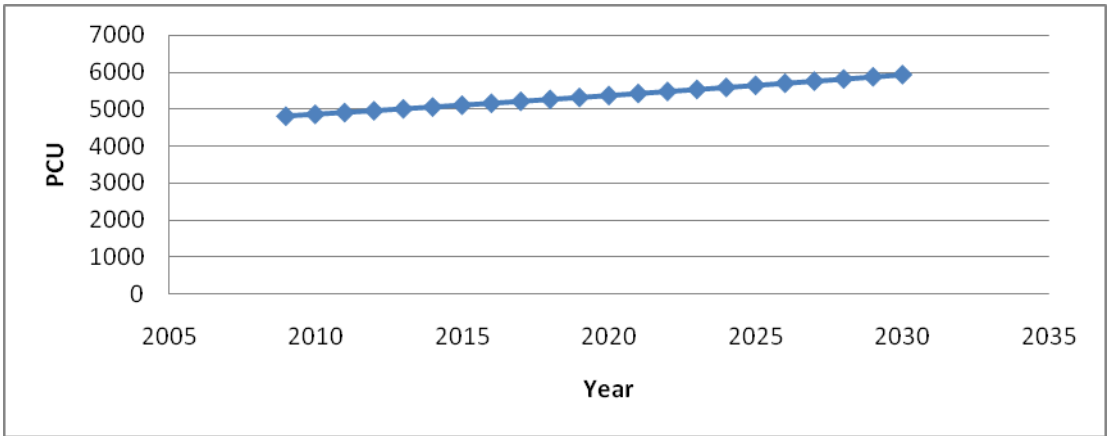


Table 2-1: Details of existing utilities

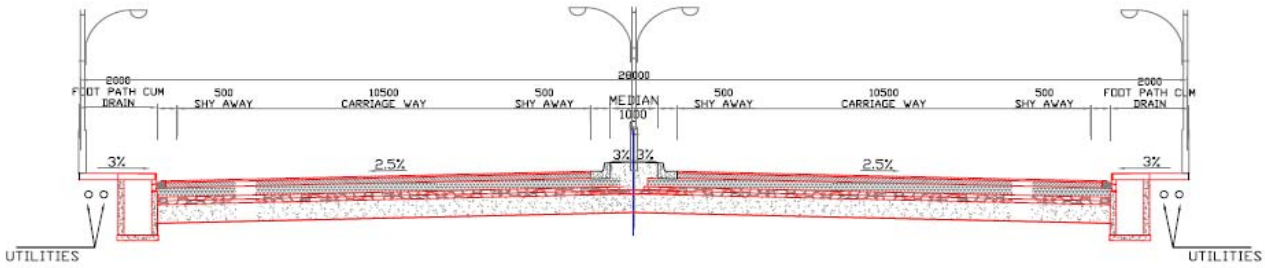
Year	PCU	V/C
2009	4,802	0.89
2010	4,850	0.90
2015	5,097	0.94
2020	5,357	0.99
2025	5,631	1.04
2030	5,918	1.10

Figure 2-2: Cordon Count Projection at NH-91



20. Hence, it is recommended that on NH 91, the stretch of the roadway between Hapur bypass grade separator and Meerut Road Y junction needs to be widened to a 6-lane divided roadway. The total length of the road proposed for the widening is approximately 4.8 km. The lane configuration proposed for this 4.8 km stretch of the road is 6L-2W-D as shown in the Figure below. It is recommended that on-street parking be prohibited at critical points.

Figure 2-3: Typical 6-lane Carriageway Cross Section



3. ENGINEERING SURVEYS & INVESTIGATIONS

A. General

21. Various engineering surveys have been carried out for the proper planning and design of the proposed road widening project. Following surveys have been carried out:

- Topographical survey
- Trial pit/subsoil investigations
- Material survey

B. Topographical Surveys

22. The basic objective of the topographic survey was to collect the essential ground features of the proposed junction using Total Station so as to develop a Digital Terrain Model (DTM), to take care of design requirements of grade separated facility, identifying areas of restriction and their remedies. The data collected will result in the final design and is also used for the computation of earthwork and other quantities required.

23. As first step of the field study, satellite imagery maps of the location were collected and examined thoroughly to have first hand information about the area and to decide on the possible improvement options. It also helped out in finalising the extent of topographical survey.

1. Detailed Survey of Topographical Features

24. Topographical survey using total station has been carried out to collect sufficient data to form the digital terrain model and to prepare the map of the physical features of the area. Following existing features have been captured during the survey:

- Building lines, type of buildings (shops or houses, number of stories), trees and Right of Way boundary if available at site by presence of boundary stones.
- Road edges, centerline, shoulders/footpaths, median etc
- Identifying all religious places, its locations, boundary lines and clear dimensions of compound walls and entrances.
- All service lines both above and below ground such as OFC cables, water and sewer pipes, gas pipes, electrical poles and cables, telephone poles and lines etc.
- Location of traffic islands, median, rotaries, dividers etc.
- Location of road side drains, clearly identifying the type (open/close), width of drain, including the beginning and end of drains.

- Positions of transformers, mast, towers etc
- Apart from the above, the names of intersecting roads and other landmarks are also recorded and incorporated in the drawing.

25. Topographic survey was carried out using Total Station of 5-sec accuracy for detailed mapping and with higher accuracy total station during the traversing (min 3 sec). As part of the survey, the following activities were carried out

(i) Installation of Bench Mark Pillars: As first step of the survey, Bench mark pillars were installed as described below:

Bench mark pillars were constructed at every 250 m interval. The pillars are in the form of concrete blocks of size 15 x 15 x 45 cm with a nail fixed at the center of the top surface were embedded up to a depth of 30 cm in to the ground. The BM pillars were painted in yellow and details such as BM number and reduced level were clearly marked. Logical numbering sequence was followed.

(ii) Cross – Sections: Cross sections along the road have been taken at every 10 m interval in longitudinal direction for a minimum width of 15m or up to the building lines from the centerline of the existing carriageway on either side of the road. Cross section levels were taken at

- Centerline of existing carriageway and median edges
- Points between centerline and edge of carriageway
- Shoulder/Footpath edges/carriageway edges
- Additional points at locations of change in ground/critical points

(iii) Longitudinal Section: Longitudinal section levels along the centerline were taken at every 10m interval. Where curves or important features were encountered, this interval was suitably reduced. Cross sections points for the required width was taken corresponding to each point in the longitudinal section.

(iv) Map Plotting: The existing features surveyed were directly imported into Computer Aided Software and the details of the same has been plotted and presented for ready reference.

C. Trial Pit/ Subsoil Investigations

1. For Pavement Design

26. *Objective*. The objective of the investigations is to provide basis for design of pavement for the service roads keeping in view the composition and characteristics of the existing pavement/sub grade. The scope of work, thus, includes collection of information regarding the existing pavement crust composition and characteristics and existing sub grade type and sub-soil conditions.

27. *Sub-grade Soil Testing*. Necessary sub soil investigations to understand the physical particulars of soil at site to enable proper pavement designs were carried out. All investigations were executed in conformation with IRC, BIS codes and MORT&H specifications. Test pits were taken along the road stretch at specified locations for the evaluation of physical properties of the sub grade soil to enable pavement design. The size of the test pit was kept as 1m x 1m x 1m. The representative samples of excavated soil from each trial pit at depth intervals GL to 0.25m, 0.25m to 0.5m, 0.5m to 0.75m and 0.75m to 1m were collected in airtight bags and properly packed and were sent to the laboratory for the required laboratory tests on these samples. The following tests were carried out to ascertain the properties of the sub-grade, base and sub-base layers of the existing road including thickness of different layers of pavement.

- Grain Size Analysis
- Atterberg Limits
- Modified Proctor
- CBR Values
- Field Density and Moisture Content

Table 3-1: Laboratory Test Results for Sub grade Area Soil

TP No	Depth	Sieve & hydrometer analysis				LL	PL	Optimum Moisture Content	Max. Dry Density	CBR value	G	d	NMC
		Gravel Content	Sand Content	Silt Content	Clay Content								
	(m)	%	%	%		%	%	%	g/cm3	%		g/cm3	%
1	GL-0.25	5	53	42	0	N -	P	10.2	1.88	8.5	2.63	1.52	4.55
1	0.25-0.50	2	57	41	0	N -	P	9.5	1.91	8.4	2.64	1.56	4.62
1	0.50-0.75	4	58	38	0	N -	P	9.2	1.88	8.6	2.62	1.54	4.48
1	0.75-1.00	2	59	39	0	N -	P	9.4	1.92	8.5	2.63	1.55	4.56
2	GL-0.25	4	53	43	0	N -	P	9.7	1.87	8.2	2.61	1.49	4.66
2	0.25-0.50	3	52	45	0	N -	P	9.5	1.92	8.4	2.6	1.51	4.55
2	0.50-0.75	7	48	45	0	N -	P	10.1	1.92	8.7	2.65	1.54	5.06
2	0.75-1.00	7	58	35	0	N -	P	9.3	1.925	8.7	2.63	1.56	5.12
3	GL-0.25	5	56	39	0	N -	P	9.5	1.89	8.2	2.64	1.5	4.3
3	0.25-0.50	4	55	41	0	N -	P	9.1	1.89	8.5	2.62	1.52	4.8
3	0.50-0.75	2	55	43	0	N -	P	9.9	1.9	7.7	2.65	1.54	5.45
3	0.75-1.00	3	54	43	0	N -	P	9.6	1.86	8.1	2.64	1.5	5.35
4	GL-0.25	0	54	46	0	N -	P	9.8	1.88	8.3	2.64	1.54	5.42
4	0.25-0.50	0	58	42	0	N -	P	9.2	1.89	7.9	2.63	1.54	4.35
4	0.50-0.75	0	57	43	0	N -	P	9.3	1.92	8.3	2.62	1.55	5.66
4	0.75-1.00	2	60	38	0	N -	P	9.1	1.94	8.6	2.62	1.54	4.38
5	GL-0.25	3	52	45	0	N -	P	9.7	1.875	8.3	2.64	1.54	5.35
5	0.25-0.50	3	53	44	0	N -	P	9.7	1.86	8.2	2.63	1.56	5.62
5	0.50-0.75	0	62	38	0	N -	P	9.1	1.93	8.8	2.62	1.49 1.54	4.38 4.62
5	0.75-1.00	2	52	46	0	N -	P	9.6	1.86	8.4	2.64	1.56	5.14

2. Soil Testing for Embankments

28. Additional tests were performed on identified borrow area materials, located at reasonable distance from the project site to ensure suitability of fill material and stability of embankment. Investigations to locate borrow areas for soil preceded the testing programmed. Test pits were excavated in borrow areas from where material for embankment was collected. The depth of each test pit did not exceed the likely depth of the borrow pit by more than 15 cm as per clause 10.3.2 of IRC –19. Samples of soil to be used in embankment were tested in the laboratory for the following properties

- Sieve Analysis
- Liquid Limit / Plasticity Index
- Moisture Content - dry density relationship using modified Proctor's Compaction
- Soaked CBR at Modified Proctor Density

29. The tests mentioned above are being carried out in accordance with the procedures laid down in IS 2720 "Methods of Tests for Soils." The test results of soil samples are presented as per IS: 1498-1959. In addition to tests already mentioned, samples of soil to be used in the top 50 cm of the embankment shall be tested in the laboratory for determination of C.B.R. Value at 100 per cent standard Proctor Density and Optimum Moisture Content, soaking the samples in water for 96 hrs. Samples of similar materials shall be molded at different densities by giving different number of blows namely 25, 45, 55 and 65 following modified Proctor's Compaction test procedure in a C.B.R mould and soaked C.B.R. tested at different densities to develop Density Vs C.B.R curve. From this curve C.B.R. at 98% modified Proctor Density shall be worked out. The C.B.R at 98% modified Proctor Density shall be used for the design of pavement as per IRC: 37-2001 "Guidelines for the Design of Flexible Pavement". The detailed test results are given in **Appendix 1**.

D. Material Survey and Analysis

30. As part of material investigation, source of construction materials like sand, aggregates, etc have been identified. The approved quarry details have been collected from the UP PWD. Information on the source of construction materials and their properties were also collected from the sites where construction work is under progress. Accordingly, it was understood that, Yamuna Nagar in Haryana about 200 km away is a known source for stone aggregates, Ghaghar, 180 km away and Haridwar, 160 km away are sources for sand and Noida, 30 km away for soil.

1. Bitumen

31. Bitumen of 80/100, 60/70, 30/40-penetration grades, Crumb Rubbiser Modified Bitumen - 55 grade and Polymer Modified Bitumen SBS 70 grade are available from HPCL and

HINCOL in Delhi.

2. Water Quality

32. Water used for construction shall be potable. Potable water is available around 1km away the junction location.

E. Identification of Utilities

33. During site studies, the presence of following utilities in the area of proposed development has been identified.

Table 3-2: Details of Existing Utilities

S. No	Utilities	Number
1	Transformer	32
2	Telephone pole	38
3	Tree	167
4	Main hole	55
5	Electric pole	260
6	Hand pump	16

4. EXISTING FEATURES, IMPROVEMENT PROPOSALS & DESIGN STANDARDS

A. General

34. Traffic congestion happens when the road demand exceeds the road capacity. This in turn increases travel time. The project stretch of NH 91, like all other arterial highways, caters for high intensity traffic the whole day through causing traffic blockage. This warrants capacity augmentation of the corridor for increasing the rate of mobility. Though the road widening proposal does not fully succeed in eliminating congestion, especially in an urban situation where there are many intersections and merging points, that is the primary option which can be considered if land width available permits. When capacity is expanded on heavily used roads, it reduces delay for a period of time, though short. Operational enhancement, such as coordinated signal timing etc. should be given top priority and shall be emphasized and ensured.

35. Based on the findings of traffic surveys described in chapter 3 the project stretch warrants six lane. The land use of the metropolitan area plays a crucial role in its transportation scenario. In a rapidly growing metropolis like Ghaziabad, new urban developments and new land uses shall generate higher population and employment densities leading to increased traffic woes. The complexities of the traffic management issues experienced in the region might not find a solution by widening the small stretch of the project road but shall present the best opportunity for managing congestion in the stretch under consideration.

B. Project Road

36. NH 91, a major National Highway corridor of India, starts from NH 2 in Kanpur and joins NH 24 in Ghaziabad. The entire length of this important highway traverses with in the state of Uttar Pradesh. It passes through important towns of Kannauj, Etah, Aligarh, and Bulandshahr before joining NH 24 and has a total length of 405 km. The project road under the present study is the last segment of NH 91 starting from Hapur bypass intersection to the end point where it joins with NH 24 having a length of 4.30 km. The full stretch comes with in Ghaziabad town. The road configuration is dual 2 lane divided carriageway of varying widths from 7.00 m to 10.5m (for each direction) separated by a central median of 1.0m width. Median openings are provided at junctions and intersections. The road carries mainly cars, two wheelers, trucks and auto rickshaws apart from comparatively lesser share of other vehicles. Railway line crosses the highway at grade at Ch: 2+700. A four lane ROB with service road on either side exists along the project road. The ROB approach starts at Ch:2+360 and ends at 3+070. Earthen shoulders are seen dotted with trees. Drains are running parallel to the project road on both sides. Lamp posts are fixed in the central median. Location of the project stretch is illustrated in **Figure 4-1**.

Figure 4-1: Location of Project Road

1. Terrain and Landuse

37. The terrain along the project stretch is plain and highly urban with many industries and commercial establishments, places of recreation, hospitals, residential areas etc. along side. There are many branch roads deviating and leading to suburban colonies, market places and industrial towns present on both sides of the road. Many religious structures are also seen abutting the road. Major share of the land use is commercial and industrial which attract large population for various purposes.

2. Existing Carriageway and Pavement Details

38. The project stretch has inconsistent carriageway width with in this short length. Four lane configurations with central median of width 1 m is available in the initial stretches which broadens to six lane configuration towards the end. The lane configuration details are given in **Table 4-1**. Carriageway consists of bituminous surface which is, in general, in good condition. Project road has bituminous pavement throughout the length. Pavement condition survey carried out along the project stretch to identify the type of distress and to estimate the extent of distress indicators, viz. Cracking, Raveling, Rutting, Pot-holes etc. Condition of the pavement is good to fair with no severe distresses. The condition of the paved shoulder is also good to and that of earthen shoulder is fair to poor. The pavement condition distribution along the project stretch is presented in **Figure 4-2**.

Figure 4-2: Condition of Payment

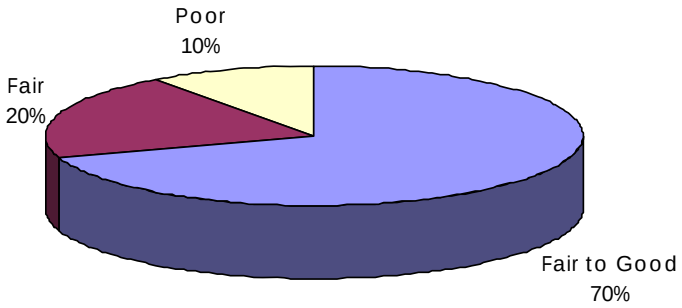


Table 4-1: Details of Lane Configuration

S. No	Utilities	Number
1	0+000 to 0+130	6-lane
2	0+130 to 0+170	4-lane
3	0+170 to 0+200	6-lane
4	0+200 to 0+240	4-lane
5	0+240 to 0+750	6-lane
6	0+750 to 0+770	4-lane
7	0+770 to 1+460	6-lane
8	1+460 to 2+360	4-lane
9	2+360 to 3+070	ROB Portion
10	3+070 to 4+300	4-lane

3. Right of Way

39. The highway stretch comes in highly urban locale with many shops and multi storied establishments abutting the road on both sides. Road inventory shows an existing right of way of 34 m to 45 m available between shop lines. No specific RoW information could be gathered from site as there are no pillars existing marking the boundary. The available average ROW for every 200m is given in **Table 4-2**.

Table 4-2: Details of ROW Available at Site

S. No	Utilities	Average ROW (m)
1	0+000 to 0+200	34.120 m
2	0+200 to 0+400	36.480 m
3	0+400 to 0+600	35.270 m
4	0+600 to 0+800	37.020 m
5	0+800 to 1+000	37.360 m
6	1+000 to 1+200	34.420 m
7	1+200 to 1+400	33.420 m
8	1+400 to 1+600	33.990 m
9	1+600 to 1+800	33.910 m
10	1+800 to 2+000	36.050 m
11	2+00 to 2+200	36.060 m
12	2+200 to 2+360	33.700
13	2+360 to 2+600	ROB Portion

S. No	Utilities	Average ROW (m)
14	2+600 to 2+800	ROB Portion
15	2+800 to 3+000	ROB Portion
16	3+000 to 3+070	ROB Portion
17	3+070 to 3+400	39.720 m
18	3+400 to 3+600	39.686 m
19	3+600 to 3+800	42.030 m
20	3+800 to 4+000	45.340 m
21	4+000 to 4+200	42.540 m
22	4+200 to 4+300	44.810 m

4. Existing Horizontal and Vertical Geometry

40. NH 91 has straight and mild curved horizontal geometry through out the project length. Mild curves are present at 0+891.984, +970.003, 2+599.923, 2+823.372 and 4+045.604 locations having large radii. As the terrain is plain, the vertical geometry of the road is flat and smooth giving good riding comfort.

5. ROB Along Project Stretch

41. The Delhi – Lucknow Railway line crosses the highway at Ch: 2+700. A Four lane ROB with at grade service road exists along the project stretch. The start and end chainage of ROB approaches are 2+360 and 3+070 respectively. Improvements of ROB along with the approaches are not envisaged in the scope of the present study.

6. Intersections and Junctions

42. There are three major intersections and three major junctions present along the stretch. Minor junctions and intersections are many in number. The junctions and intersections along the project road are given in **Table 4-3** and **Table 4-4**. No elevated or underground crossings are observed along the stretch considered for widening, except the ROB mentioned above.

Table 4-3: Intersections along the Project Road

S. No	Chainage	Cross Roads Forming Intersections
1	0+035	Chopila Temple – Sarai Nagar Colony
2	0+185	Ghantaghar Market-Railway station road
3	0+780	Church School-Palika Market
4	1+000	Chowdary Chowk
5	1+560	Navghar Cinema Chowk
6	2+360	Bhatya Chowk
7	3+300	Lohamandi-Industrial area
8	3+650	Kavi Nagar – Industrial area
9	4+000	Yadav Nagar – Industrial Area

Table 4-4: Junctions along Project Road

S. No	Chainage	Junctions
1	0+275	Gole Market
2	0+630	Ramteram Chowk
3	1+960	Rakesh Market
4	0+400	Ramleela Gate
5	0+830	Kiranamandi
6	1+500	Navarang Cinema
7	1+700	Kiran Enclave
8	1+800	Shyam Vihar
9	1+860	Model Town West
10	2+200	Sudharshan Hospital
11	2+550	Jai prakash Nagar
12	3+140	Lohamandi

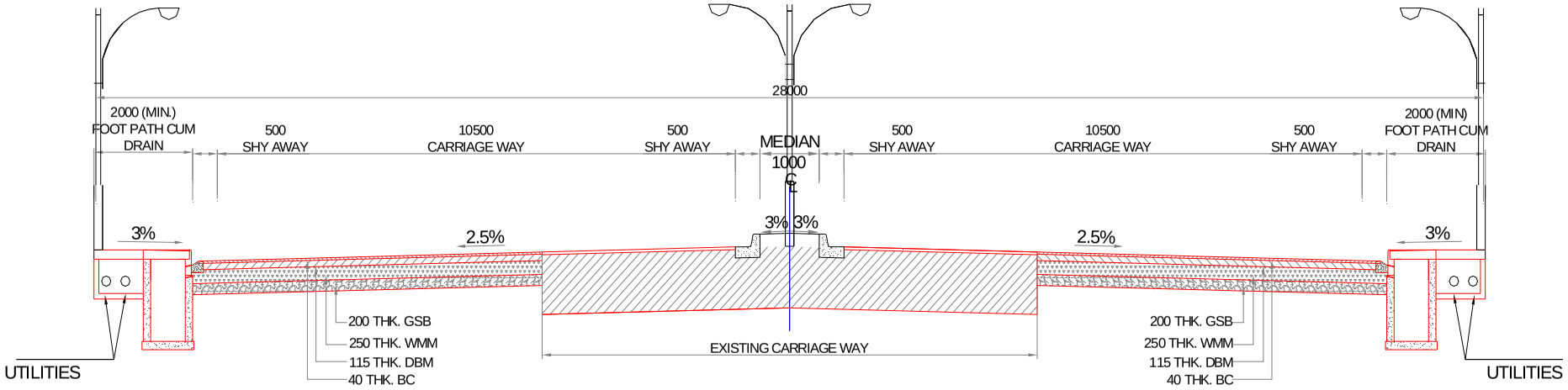
C. Need for Improvement and Proposal

43. Detailed analysis of traffic data warrants widening of the existing facility. Accordingly, a six lane divided carriageway is proposed with drain cum footpath on both the sides. Geometric improvements to the existing facility are also planned. The salient proposals for the improvement of the stretch of project road are classified into the following engineering aspects:

- Widening of the project road into 6 lane configurations based on traffic capacity requirement
- Concentric widening is proposed for the entire project stretch
- Improving the geometry of the existing road based on the design standards
- Design of new pavement for widening and strengthening of the existing road
- Improvements to all major and minor intersections and Junctions
- Provision of road furniture for safety

44. A typical cross section for widening is shown in **Figure 4-3**.

Figure 4-3: Typical Six Lane Carriageway Cross Section



1. Geometric Improvements

45. Major horizontal or vertical geometric improvements are not found to be essential as the terrain is plain and existing alignment is more or less straight with large radius for curves. There are no constraints to adopt the design speed as mentioned in the design standards. However, minor improvements in geometry, wherever found required, have been carried out.

D. Design Standards

46. The purpose of formulation of design standards is to fix project specific standards for the various design elements which will suit the site condition and that will be used during various stages of design.

1. Geometric Standards

47. As the project stretch falls with in urban limits, relevant IRC design standards with due consideration to the latest directive and guidelines of MOSRTH/IRC was followed while formulating the highway design standards. Other relevant standards were also referred to wherever found relevant. For the geometric design IRC: 86-1983 “Geometric Design Standards for Urban Roads in Plains” is followed, as the entire project stretch falls within the city limits. Apart from the above said standards the following standards are also referred to in carrying out the geometric desig:

- IRC: 86-1983 “Geometric design standards for urban roads in plains.
- IRC: 37-2001 “ Guidelines for the design of flexible pavements”
- IRC: SP-41-1994 “ Guidelines for the design of At-Grade intersection in rural & urban areas”
- IRC:103-1988 “ Guidelines for pedestrian facilities”
- IRC: 32-1969 “Standard for vertical & horizontal clearances of overhead electric power and telecommunication lines as related to roads.”
- IRC: 98-1997 “Guidelines on accommodation of utility services on roads in urban areas.”
- IRC: SP-42-1994 “Guidelines on road drainage.”
- IRC: 35-1997 “Code of practice for road markings”
- IRC: 67-2001 “ Code of practice for road signs”
- IRC: 81-1997 “Tentative Guidelines for Strengthening of Flexible Road Pavement”
- IRC: SP:23-1983 “Vertical Curves for Highways”

48. Reference to other codes of practice and special literatures are made where found required. **Table 4-5** shows the geometric design standards proposed for this project based on IRC stipulations for horizontal and vertical alignments.

Table 4-5: Geometric Design Standards

S. No	Description		IRC Standards		
1	Design speed Plain		Max – Min 100- 80 km/hr		
2	Lane width			3.5 m	
3	Median Width			1.0m	
4	Shy away on median edge			0.5m	
5	Cross-slopes		Carriageway	2.5 %	
6	Minimum horizontal curve radiu		For 100 Km/hr For 80 Km/hr	360 m 230 m	
7	Radii beyond which super elevation not required		For 100 Km/hr For 80 Km/hr	1800 m 1100 m	
8	Gradient	Plain and Rolling Terrain	Ruling Gradient Limiting Gradient Exceptional Gradient	3.3 % 5 % 6.7%	
9	Minimum Length of Vertical Curves / Grade change not requiring vertical curve		Design Speed	Min. curve length	Max. grade change
			For 100 Km/hr For 80 Km/hr	60 m 50 m	0.5 % 0.6 %
10	Vertical curve 'K' values Crest vertical curve/Sag vertical curve		For Design Speed For 100 Km/hr For 80 Km/hr	Crest 74 33	Sag 42 26

2. Design Speed

49. The design speeds adopted for various categories of road are as follows:

- Design Speed of 100 km/hr is adopted in general. (Even though geometrical conditions permit 100 km/hr, the speed is restricted to 80 km/hr because of heavy built-up).
- Design speed of 30 kmph for junction locations.

3. Carriageway Width

50. Based on the traffic requirement, six lane is required. A three lane dual carriageway is proposed with a total width of 28.0m. Out of which 10.5m carriageway, 0.5m shy away on both edges of carriageway and 2.0m footpath cum drain is proposed for each 3 lane.1.0m width median is proposed at center.

4. Camber

51. Camber of 2.5% is proposed for carriageway and 3% for footpath portion.

E. Design of Pavement

52. Pavement is designed based on MOST/IRC standards. A design life of 15 years is adopted for the design of the 6 lane carriageway. As revealed in the traffic survey, cumulative number of commercial vehicles constituting trucks, buses and LCV's are 4,224 in numbers per day and the cumulative number of msa is 45 for 15 years design period. Separate design is carried out for the main carriageway and service roads which cater for less number of standard axles.

53. Based on the result of laboratory tests carried out on the sub grade samples collected from the project stretch the project road has been designed adopting a CBR value of 8 percent.

54. The following guidelines have been followed for design of pavement:

- Guidelines for design of flexible pavements IRC-37, 2001.
- Guidelines for the Design of Overlay of Flexible Pavements IRC-81, 1997.

55. Various design parameters for the pavement design is briefly discussed below.

(i) Design Traffic in CMSA: The design traffic has been computed following the VDF and lane distribution factor as stated below and the relationship stated in para 3.3.6.1 of IRC-37.

(ii) Vehicle Damage Factor (VDF): VDF is defined as equivalent number of standard axles per commercial vehicle. It is a multiplier to convert the number of commercial vehicles of different axle loads and axle configuration to the number of standard axle load repetitions.

(iii) Vehicle damage factor for individual commercial vehicles is taken separately as per IRC standard and is taken as 3.5 for initial traffic less than 1500 & 4.5 for initial traffic more than 1500.

(iv) Lane Distribution Factor: Since the present study is for the construction of dual three lane road, the design is based on 60% of the total number of commercial vehicles in each direction.

(v) The Design Traffic has been estimated from AADT, VDF and lane distribution factor: Assuming that the construction period is of 15 months, the design traffic in terms of cumulative number of standard axles for design life periods of 15 years were obtained as per IRC 37.

(vi) For service roads, design traffic of 15 msa (30% of main traffic) has been considered.

(vii) Design Sub grade CBR: Review of the test results of the sub grade along project road alignment (within the ROW) shows that the existing sub grade CBR value is 8%.

(viii) Pavement Structural Design: Considering the sub grade soil design CBR of 8 % and design traffic 45 msa for 15 years design period, the new flexible pavement

thicknesses obtained as per IRC 37 works out as given in **Table 4-6**.

Table 4-6: Flexible Pavement Compositions

For Design period of 15 years and & Sub grade CBR of 8%.				Total Pavement Thickness (mm)
Design Traffic in terms of Cumulative Number of Million Standard Axles	Flexible Pavement Composition			
	Granular Base & Sub-Base (mm)	Bituminous Surfacing		
		DBM (mm)	BC (mm)	
For Main Carriageway 45 MSA	Base = 200 Sub base = 250	150	40	640

F. Junction Improvements

56. All the major and minor junctions along the project road are at grade junctions which shall be improved during the widening.

G. Drains

57. The surface run-off drainage of the Project Highway within its ROW comprises longitudinal drains on each side, which collects the surface run-off within the ROW and from the adjacent lands sloping towards the Project Highway; these are discharged into the natural nalas, rivulets. Box type drains are proposed along the project stretch.

H. Lightings

58. The lighting system of the Project Highway is to be given a face-lift since it is falling in highly urban locality. All light posts erected in the median or edge of the road shall have adequate height such that a uniform illumination of 40 lux is made certain.

I. Road Furniture - Road Signage and Markings

59. Road markings and road signs are provided as per IRC: 35 -1997 and IRC: 67 -2001 respectively. Traffic signs are provided at appropriate locations to caution and to give information to the drivers for ensuring safety. All signs are of retro-reflective type. The summary of traffic signs and road furniture proposed along the project road are given in **Table 4-7**.

Table 4-7: Proposed Road Furniture along the Project Road

S. No	Description	Unit	Quantity
1	Triangular Regulatory Signs (900mm sides)	No.	18
2	Stops Signs (900mm octagonal)	No.	17
3	Cautionary Sign Boards	No.	18
4	Facility Information Signs (600mm x 800mm)	No.	8
5	Direction and Place Identifications Signs	No.	4
6	Overhead Gantry Sign Boards	No.	1
7	Raised Pavement Marker (Cat's Eyes)	No.	1,912
8	200m stones (Both Sides)	No.	34
9	Kilometer Stones (Both Sides)	No.	5
10	Boundary Stones (Both Sides)	No.	288

J. Utility Relocation

60. Proposal for shifting the utilities which fall within the alignment have been prepared. The details of utilities falling along the project alignment is mentioned in **Chapter 2**. Trees falling along the proposed project alignment have to be felled during the construction. As compensatory measure, it is proposed to plant thrice the number of trees to be felled with site specific indigenous species and also to transplant the small trees wherever possible. For all the remaining utilities, shifting proposal is given in separate drawing.

61. Detailed drawings are given in **Volume V-B2: Detailed Drawings**

5. BILL OF QUANTITIES COST ESTIMATES

A. Bill of Quantities

62. Total item wise quantities for flyover are calculated as per the detailed drawings. Separate heads for all different items of work is included in the BOQ. The major work items considered are:

(i) Earth work
- Excavation
- Approach sub grade

(ii) Pavement works
- Granular sub base
- Wet mix macadam
- Bituminous works

(vii) Road Marking and Traffic Signages

(viii) Drains
- RCC Drains
- Kerb Stones

B. Rate Analysis

63. The unit rates shall be arrived by considering the basic rates, lead distances, man power, machinery, and materials. The unit rate for every individual item will be arrived based on MORTH schedule of rates applicable and standard schedule of rates for Uttar Pradesh for the district Gaziabad 2008. For items of work with no rates specified in the schedule of rates, market rates are obtained and used.

C. Estimated Costs

64. Costs summary of the proposed road widening project is presented in the following **Table 5-1**. The total estimated cost is INR 236 million. Detailed item-wise estimated, bill of quantities and rate analysis is presented in **Volume V-B3: Detailed Estimates**.

Table 5-1: Summary of Cost Estimates

Bill No.	Bill name	Amount (INR)
1	Site Clearance and Dismantling	172,291.00
2	Earthwork	2,966,719.00
3	Sub-base and Base Courses	21,962,774.00
4	Bituminous Works	113,912,989.00
5	Traffic Signages, Road Marking and Other Appurtenances	1,490,488.00
6	Drainage and Protective Works, Ducts & Other Services	95,472,019.00
	Total Construction Cost	**235,977,280.00**

PART-III

MATERIAL INVESTIGATION IN SECTION OF NH 91 NEAR MOHAN NAGAR

CONTENTS

SL. No.	CHAPTER	PAGE NO.
1.0	Location	74
2.0	Scope of Material Investigations	74-75
3.0	Field Work	75
4.0	Laboratory Tests	75-76
5.0	Findings of Material Investigations & Recommendations	76-77
	Compactions & CBR curves	78-117

1.0 LOCATIONS: Location and type of sampling for material investigation are as following.

Sl. No.	Location	Type of sampling	Numbers	Tentative length/size
1.	Section of NH 91	Trial pits	5	1.0m x 1.0 x 1.0m

2.0 SCOPE OF MATERIAL INVESTIGATION: The scope of material investigation is as following

Sl. No.	Description	Tests to be conducted on samples
1.	Along Road stretch soil collected at 1.0m x 1.0mx	At each Km along road stretch or where the soil profile changes whichever is

	1.0m pits	earlier.
2.	Gravel. Sand and Metal quarry	Tests for various samples taken at each probable quarries for sand, gravel and metal.
3.	Borrow area soil for sub grade and embankment construction	Tests for soils samples taken at each location of various borrow pits
4.	Soil stabilization methods using locally available materials.	Tests for various stabilized soil using various techniques for increasing bearing capacity of soil for foundations and construction of road and embankments

3.0 FIELD WORK:

The trial pits of sizes 1.0m x 1.0m x 1.0m were excavated along the road stretch at specified locations with the help of shovels & spades. The representative samples of excavated soil from each pit at depth intervals GL. to 0.25m, 0.25m to 0.5m, 0.5m to 0.75m and 0.75m to1.0m were collected in airtight bags and properly packed and were sent to the laboratory for the required laboratory tests on these samples.

4.0 LABORATORY TESTS:

The following laboratory tests were conducted on soil samples taken from road side pits/ borrow pits and gravels from quarry and stabilized soil mixes

a) Natural Moisture Content & field densities

b) Sieve analysis and hydrometer analysis

c) Atterberg's limits

d) specific gravity

e) bulk and dry density for soil. Density index for sand

f) shear strength parameters

h) Moisture content- density relationship

(Modified Proctor Compaction Test (as per IS:2720, Part-VIII)

i) California Bearing Ratio (CBR Value, %)

(As per IS: 2720, Part-XVI, at 95% of MDD corresponding to Modified Proctor Compaction Test)

5.0 FINDINGS OF MATERIAL INVESTIGATION & RECOMMENDATIONS:

The results of various laboratory tests conducted on representative soil samples collected from trial pits are given as below and are recommended for design purposes:

T.P. No.	Depth	Sieve& hydrometer analysis				LL	PL	OMC	MDD	CBR Value	G	r_d	NMC
		Gravel	Sand	Silt	Clay							gm/cc	%
	(m)	%	%	%	%	%	%		gm/cc	%			
1	GL.-0.25	5	53	42	0	N -	P	10.2	1.88	8.5	2.63	1.52	4.55
1	0.25-0.50	2	57	41	0	N -	P	9.5	1.91	8.4	2.64	1.56	4.62
1	0.50-0.75	4	58	38	0	N -	P	9.2	1.88	8.6	2.62	1.54	4.48
1	0.75-1.0	2	59	39	0	N -	P	9.4	1.92	8.5	2.63	1.55	4.56
2	GL.-0.25	4	53	43	0	N -	P	9.7	1.87	8.2	2.61	1.49	4.66
2	0.25-0.50	3	52	45	0	N -	P	9.5	1.92	8.4	2.60	1.51	4.55
2	0.50-0.75	7	48	45	0	N -	P	10.1	1.92	8.7	2.65	1.54	5.06
2	0.75-1.0	7	58	35	0	N -	P	9.3	1.925	8.7	2.63	1.56	5.12
3	GL.-0.25	5	56	39	0	N -	P	9.5	1.89	8.2	2.64	1.50	4.30
3	0.25-0.50	4	55	41	0	N -	P	9.1	1.89	8.5	2.62	1.52	4.80
3	0.50-0.75	2	55	43	0	N -	P	9.9	1.90	7.7	2.65	1.54	5.45
3	0.75-1.0	3	54	43	0	N -	P	9.6	1.86	8.1	2.64	1.50	5.35
4	GL.-0.25	0	54	46	0	N -	P	9.8	1.88	8.3	2.64	1.54	5.42
4	0.25-0.50	0	58	42	0	N -	P	9.2	1.89	7.9	2.63	1.54	4.35
4	0.50-0.75	0	57	43	0	N -	P	9.3	1.92	8.3	2.62	1.55	5.66
4	0.75-	2	60	38	0	N -	P	9.1	1.94	8.6	2.62	1.54	4.38

	1.0												
5	GL.-0.25	3	52	45	0	N -	P	9.7	1.875	8.3	2.64	1.54	5.35
5	0.25-0.50	3	53	44	0	N -	P	9.7	1.86	8.2	2.63	1.56	5.62
5	0.50-0.75	0	62	38	0	N -	P	9.1	1.93	8.8	2.62	1.49 1.54	4.38 4.62
5	0.75-1.0	2	52	46	0	N -	P	9.6	1.86	8.4	2.64	1.56	5.14

Where

LL - Liquid Limit

PL -Plastic Limit

OMC - Optimum Moisture Content

MDD – Maximum Dry Density

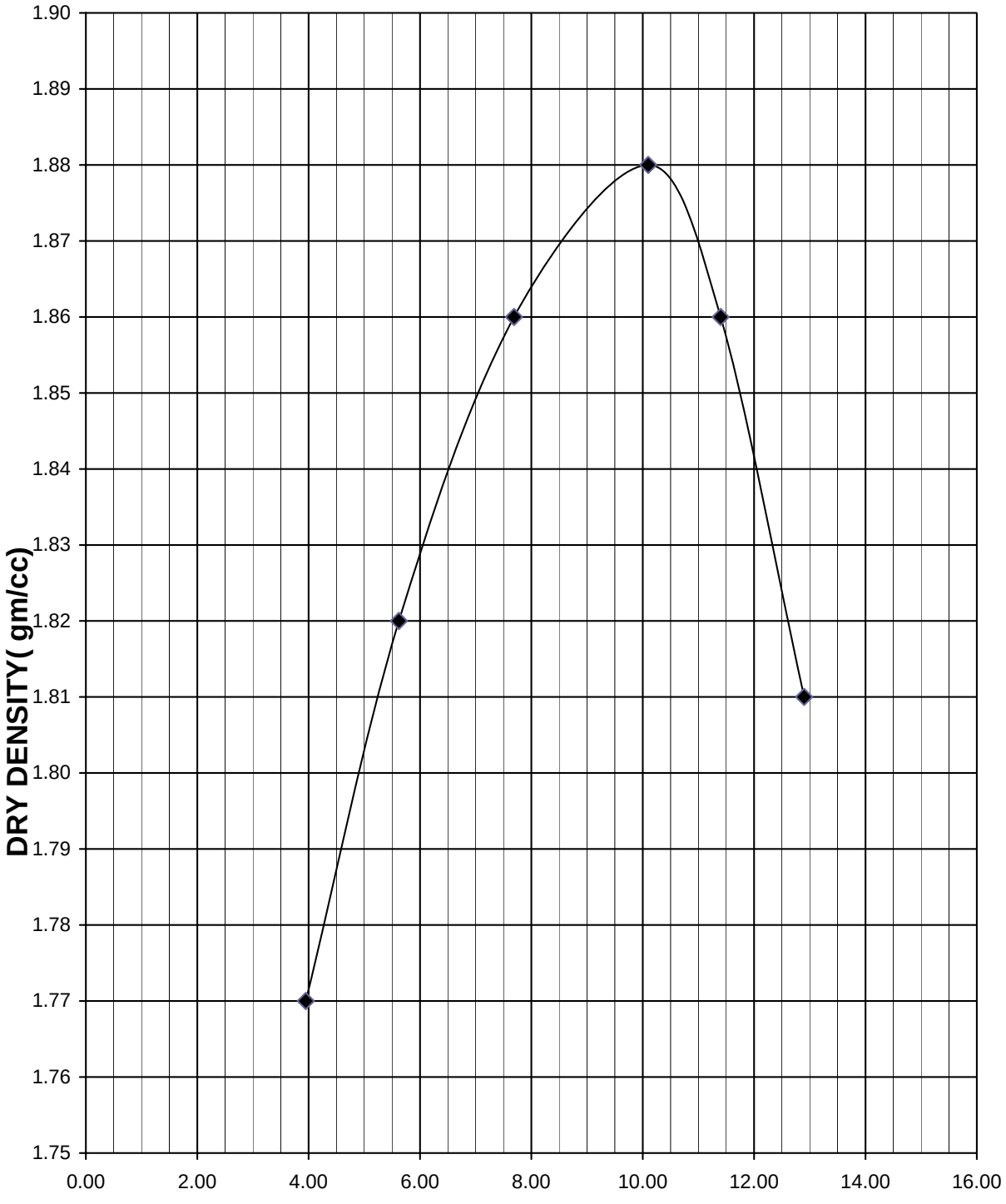
CBR – California Bearing Ratio

G – Specific Gravity

γ_d – Dry density

NMC – NATURAL Moisture Content

The relevant density-moisture relationship curves and CBR Curves are enclosed with this report.

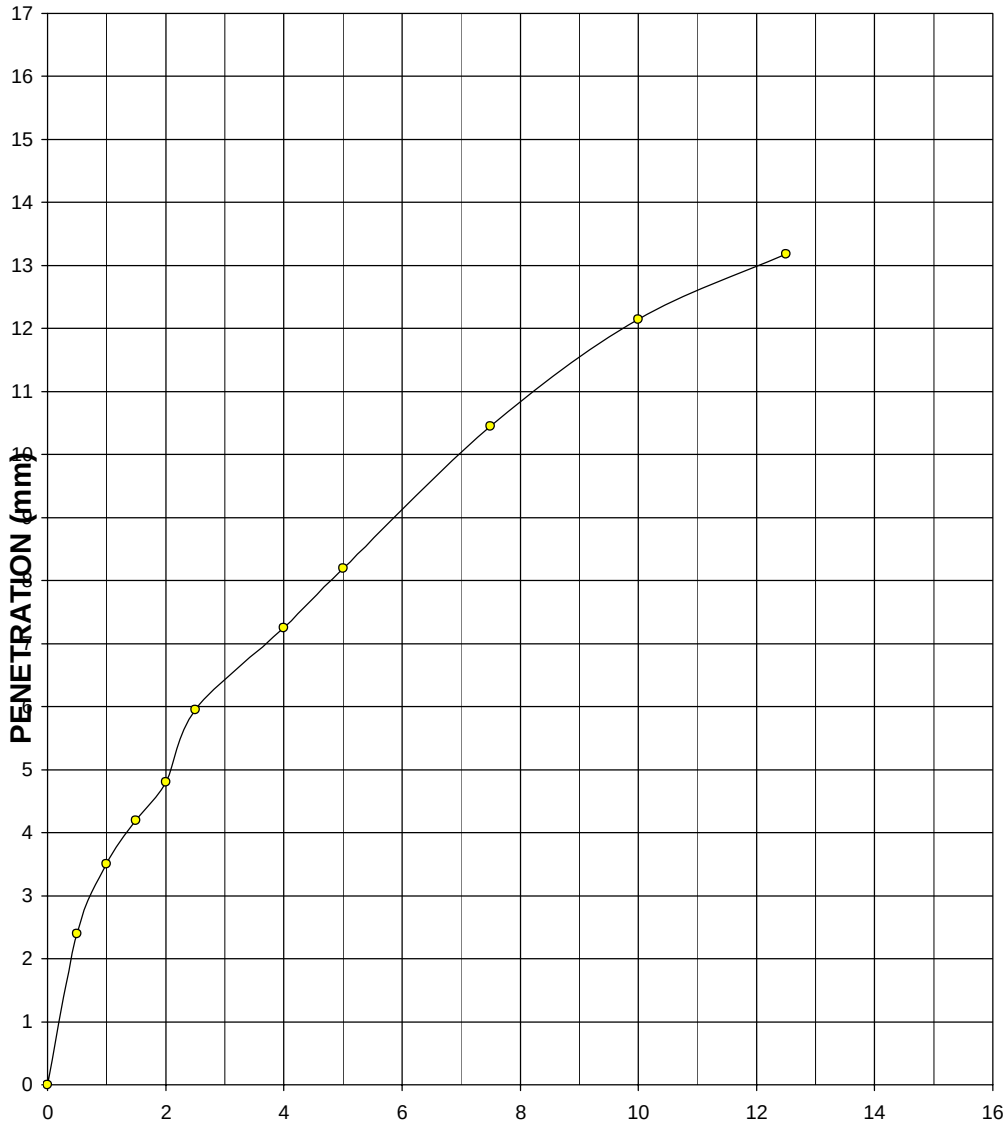


COMPACTION CURVE

Trial Pit No. - 1 Depth (m) GL. TO 0.25

SHEET NO. 79

CORRECTEDLOAD ON PLUNGER IN Kg/cm2



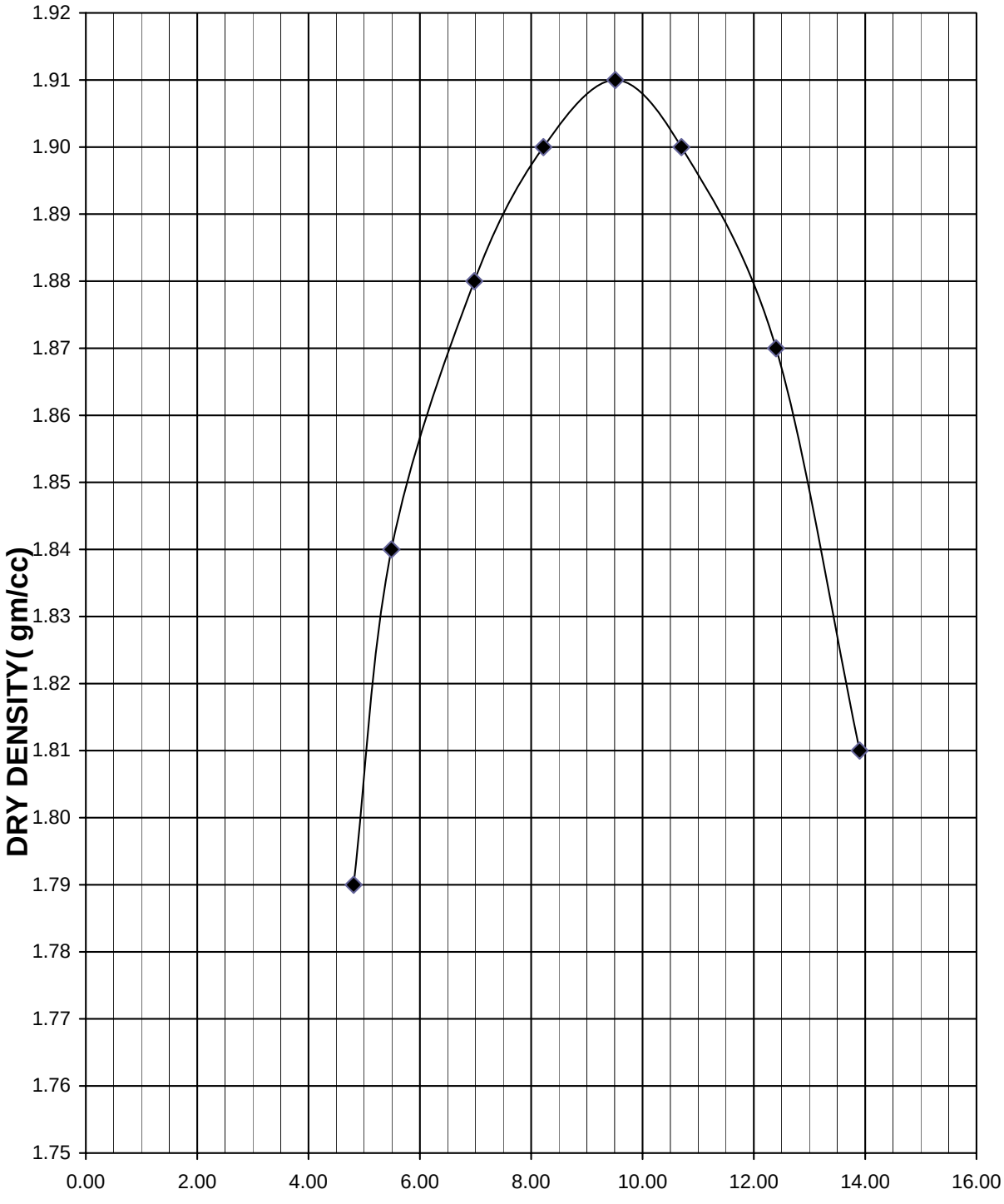
CBR CURVE

Penetration, mm	CBR,%
2.5	8.5
5.0	8.2

TRIAL PIT NO. 1 Depth (mm) GL. to 0.25

MAVERICK ENGINEERS

Sheet NO. 80

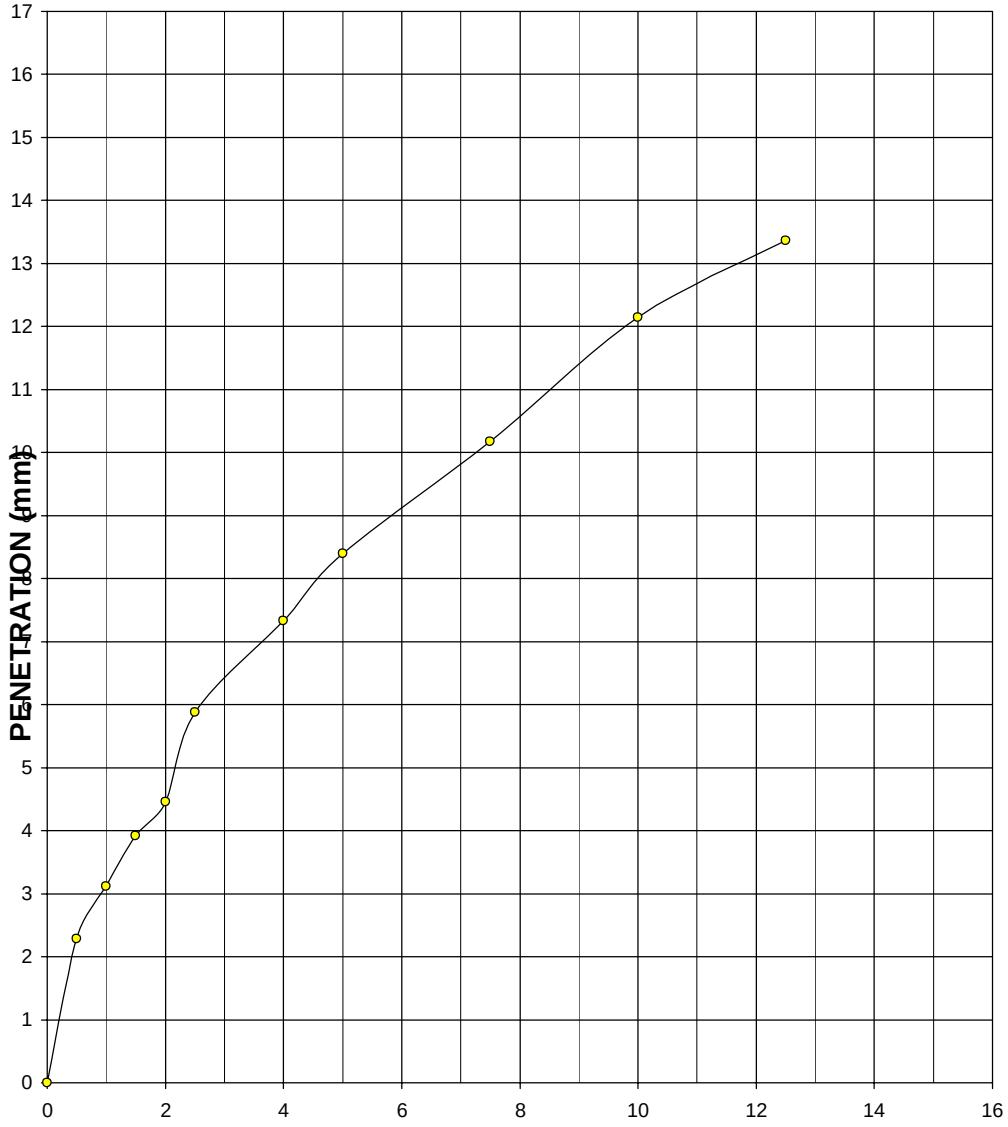


COMPACTION CURVE

Trial Pit No. - 1 Depth (m) 0.25 To 0.50

SHEET NO. 81

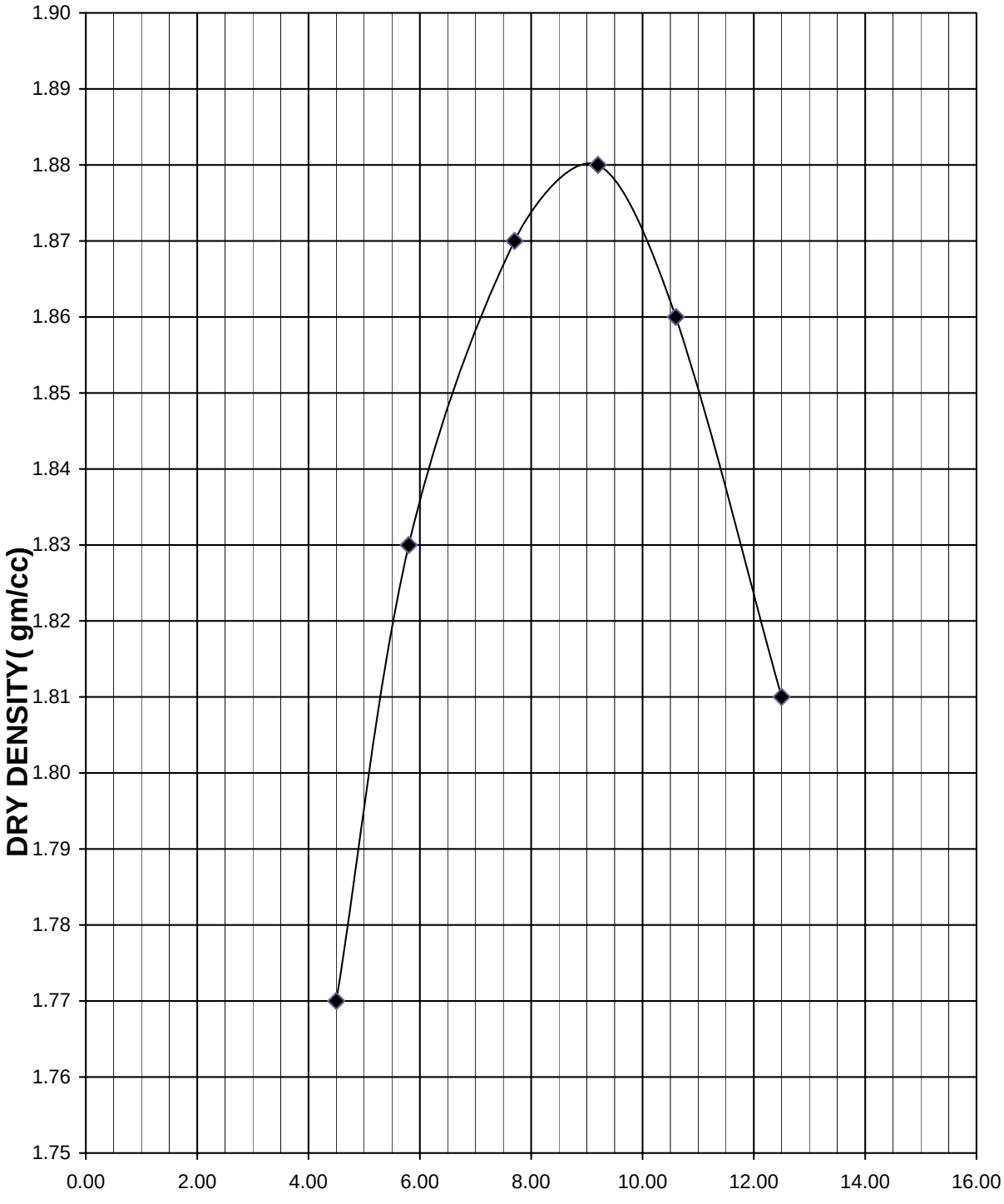
CORRECTEDLOAD ON PLUNGER IN Kg/cm2



CBR CURVE

Penetration, mm	CBR,%
2.5	8.4
5.0	8.0

TRIAL PIT NO. 1 Depth (mm) 0.25 to 0.50

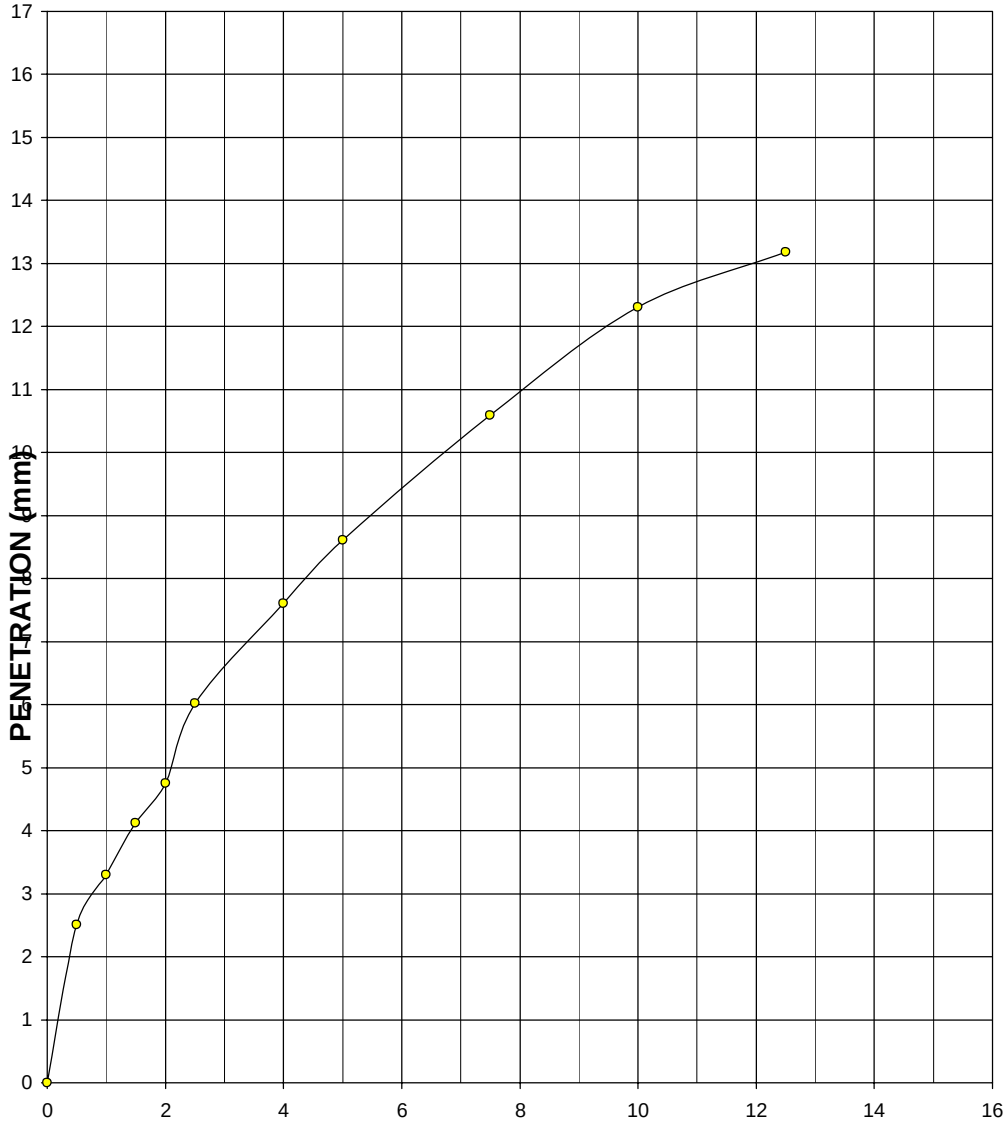


COMPACTION CURVE

Trial Pit No. - 1 Depth (m) 0.50 To 0.75

SHEET NO. 83

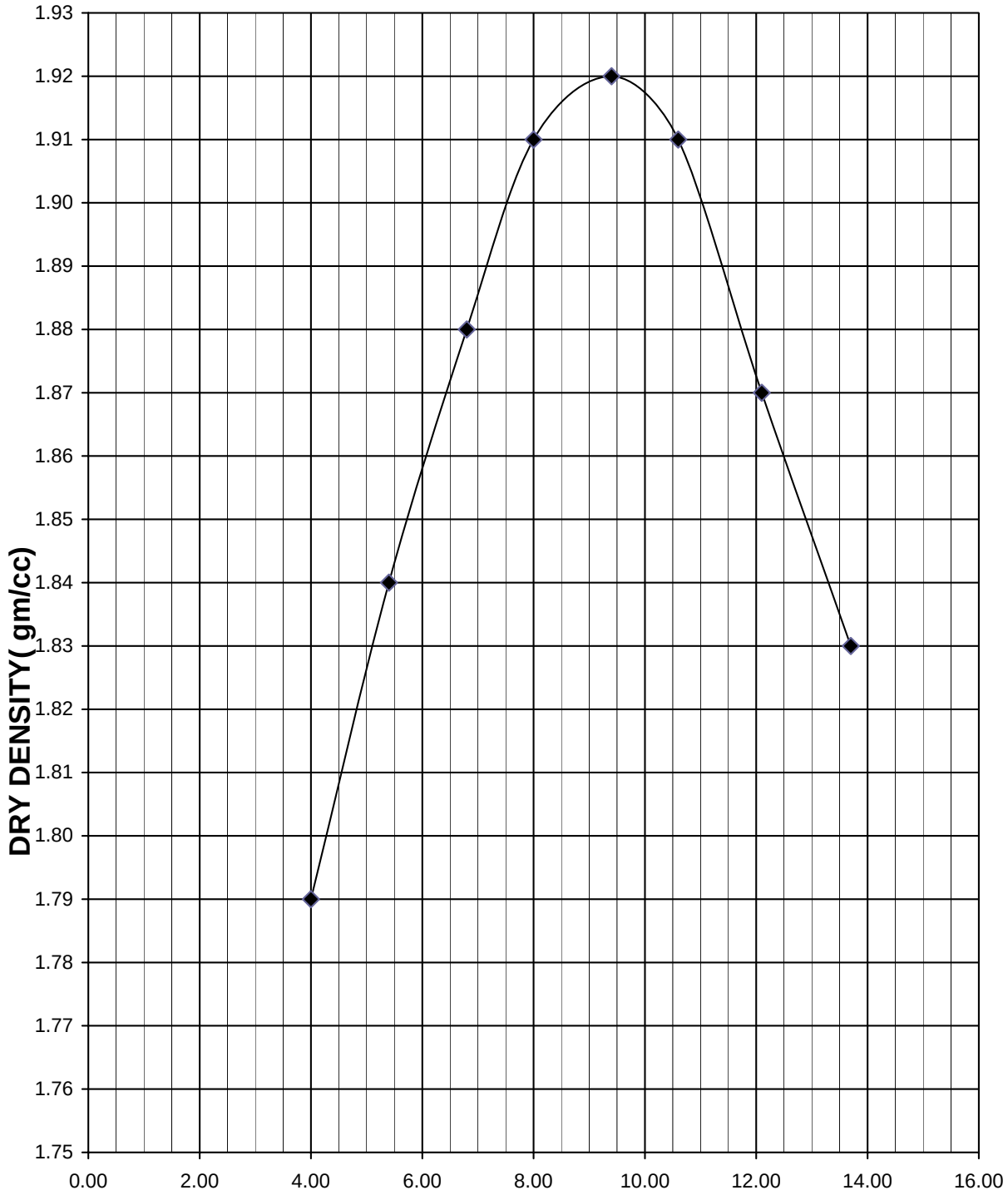
CORRECTEDLOAD ON PLUNGER IN Kg/cm2



CBR CURVE

Penetration, mm	CBR,%
2.5	8.6
5.0	8.2

TRIAL PIT NO. 1 Depth (mm) 0.50-0.75

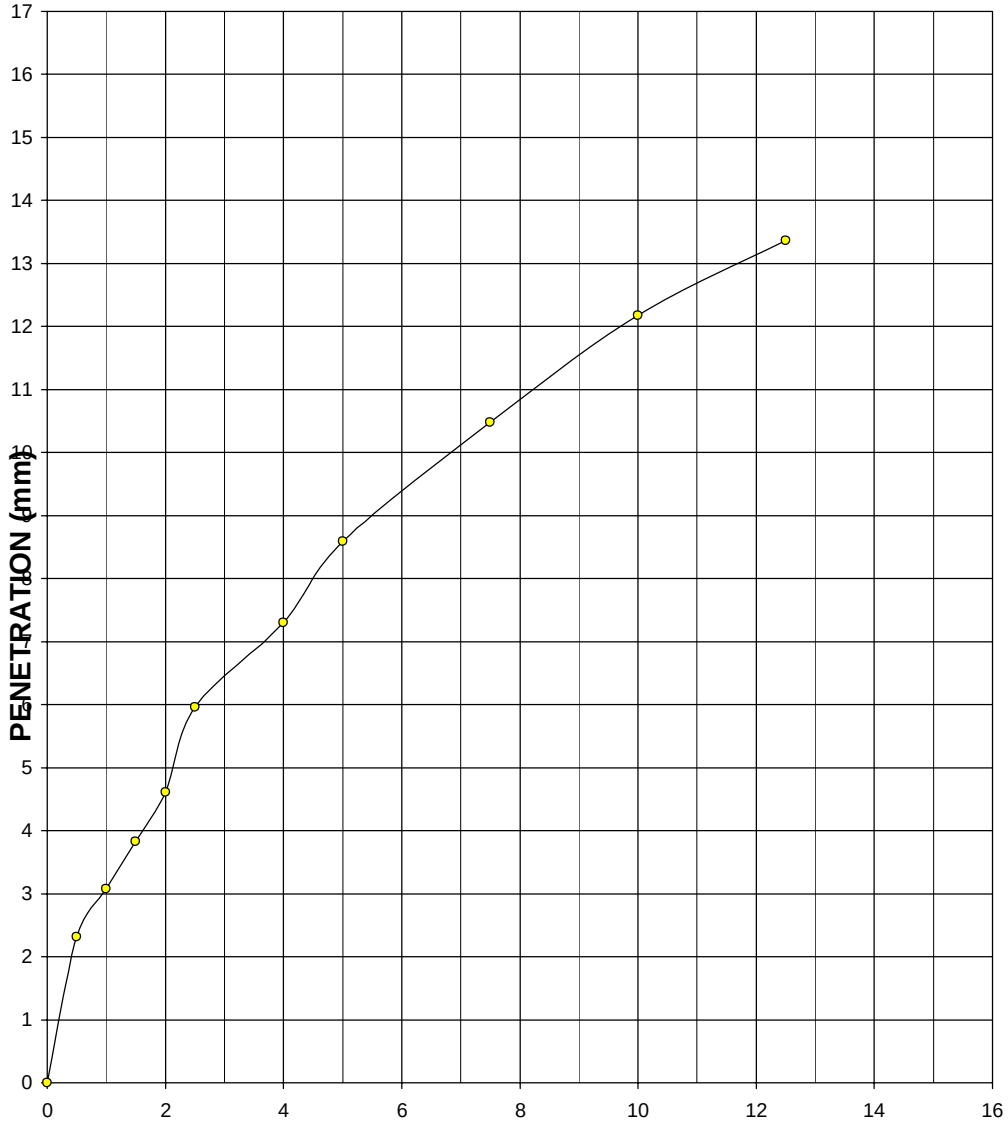


COMPACTION CURVE

Trial Pit No. - 1 Depth (m) 0.75 To 1.00

SHEET NO. 85

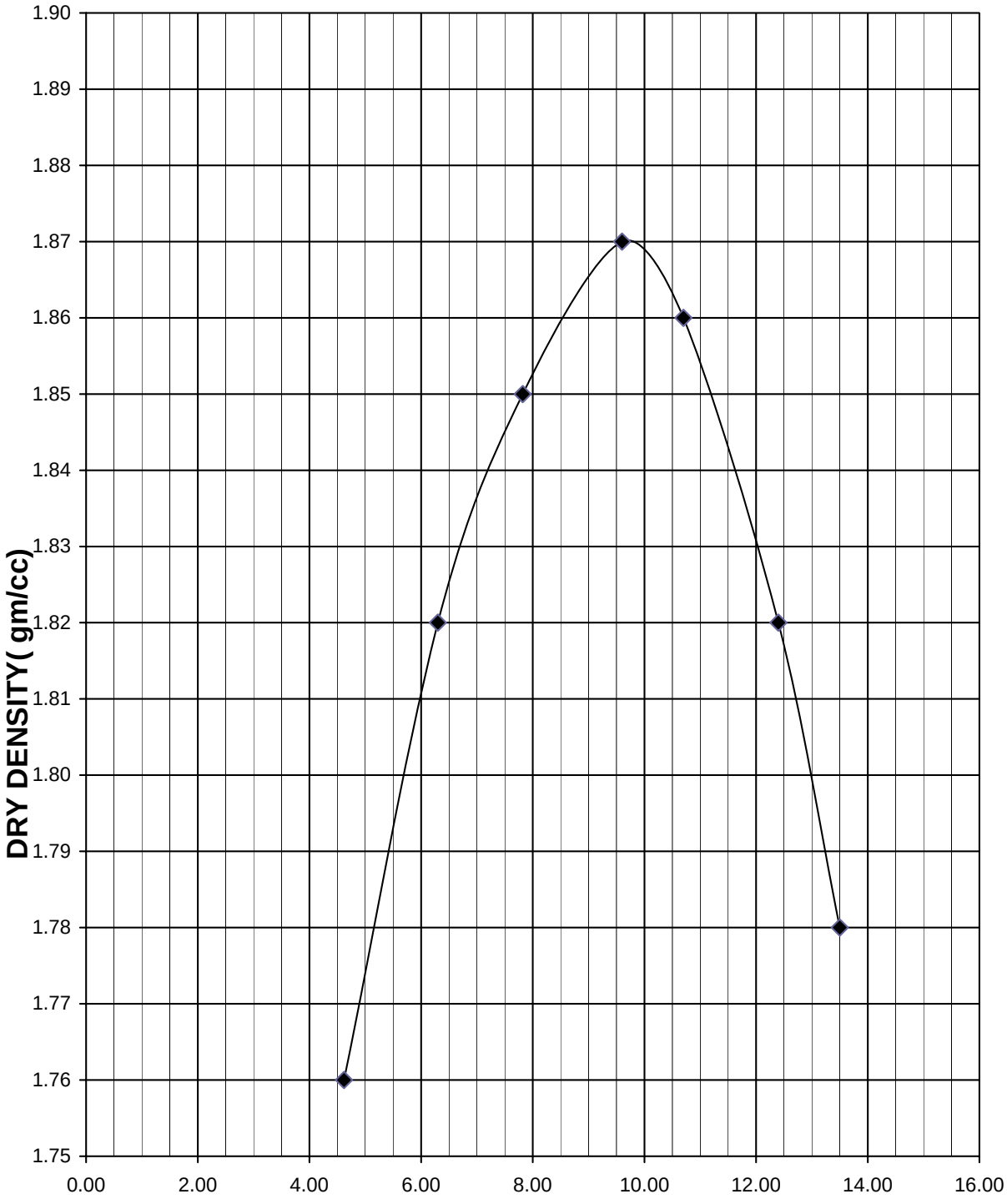
CORRECTEDLOAD ON PLUNGER IN Kg/cm2



CBR CURVE

Penetration, mm	CBR,%
2.5	8.5
5.0	8.2

TRIAL PIT NO. 1 Depth (mm) 0.75 to 1.00

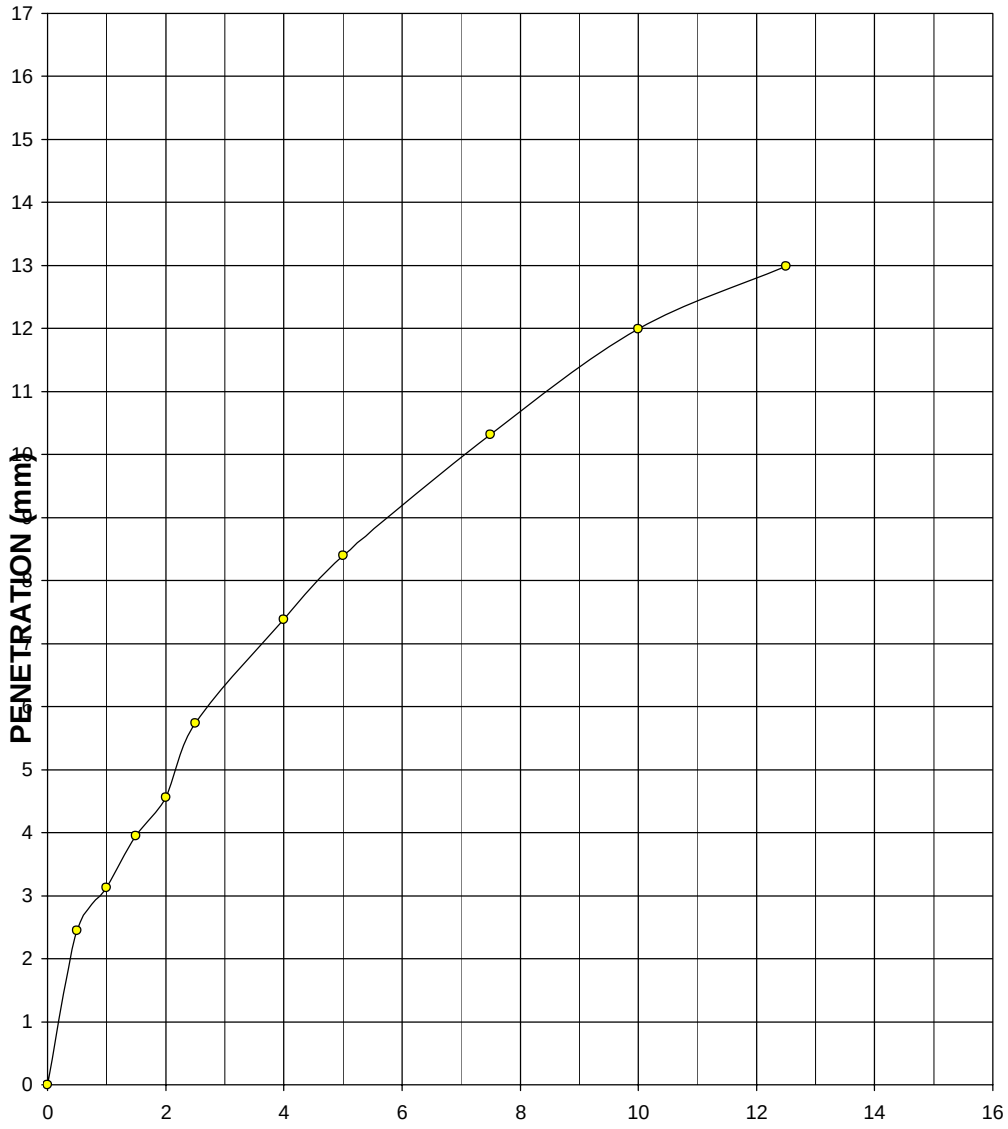


COMPACTION CURVE

Trial Pit No. - 2 Depth (m) GL. TO 0.25

SHEET NO. 87

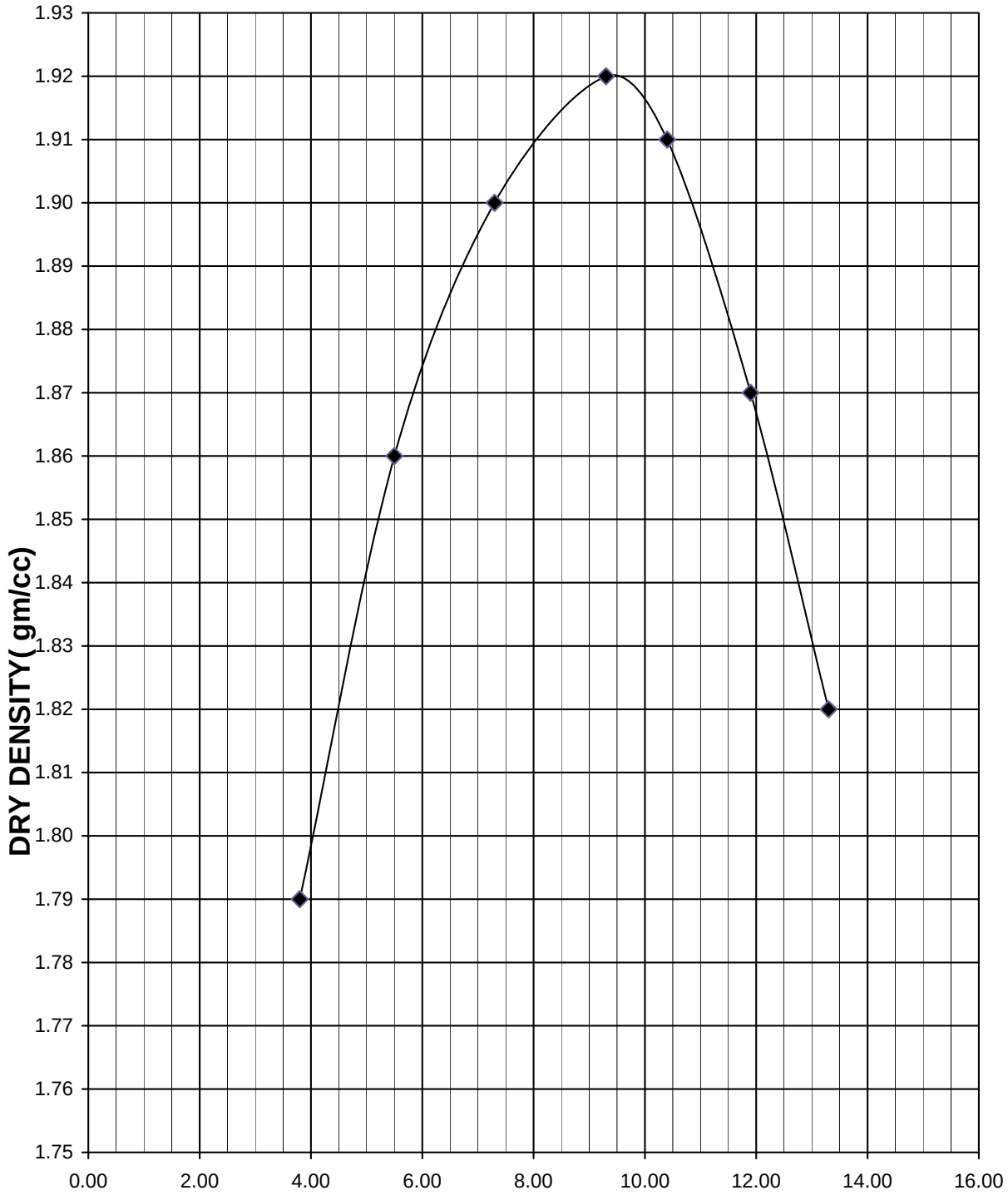
CORRECTEDLOAD ON PLUNGER IN Kg/cm2



CBR CURVE

Penetration, mm	CBR,%
2.5	8.2
5.0	8.0

TRIAL PIT NO. 2 Depth (mm) GL. to 0.25

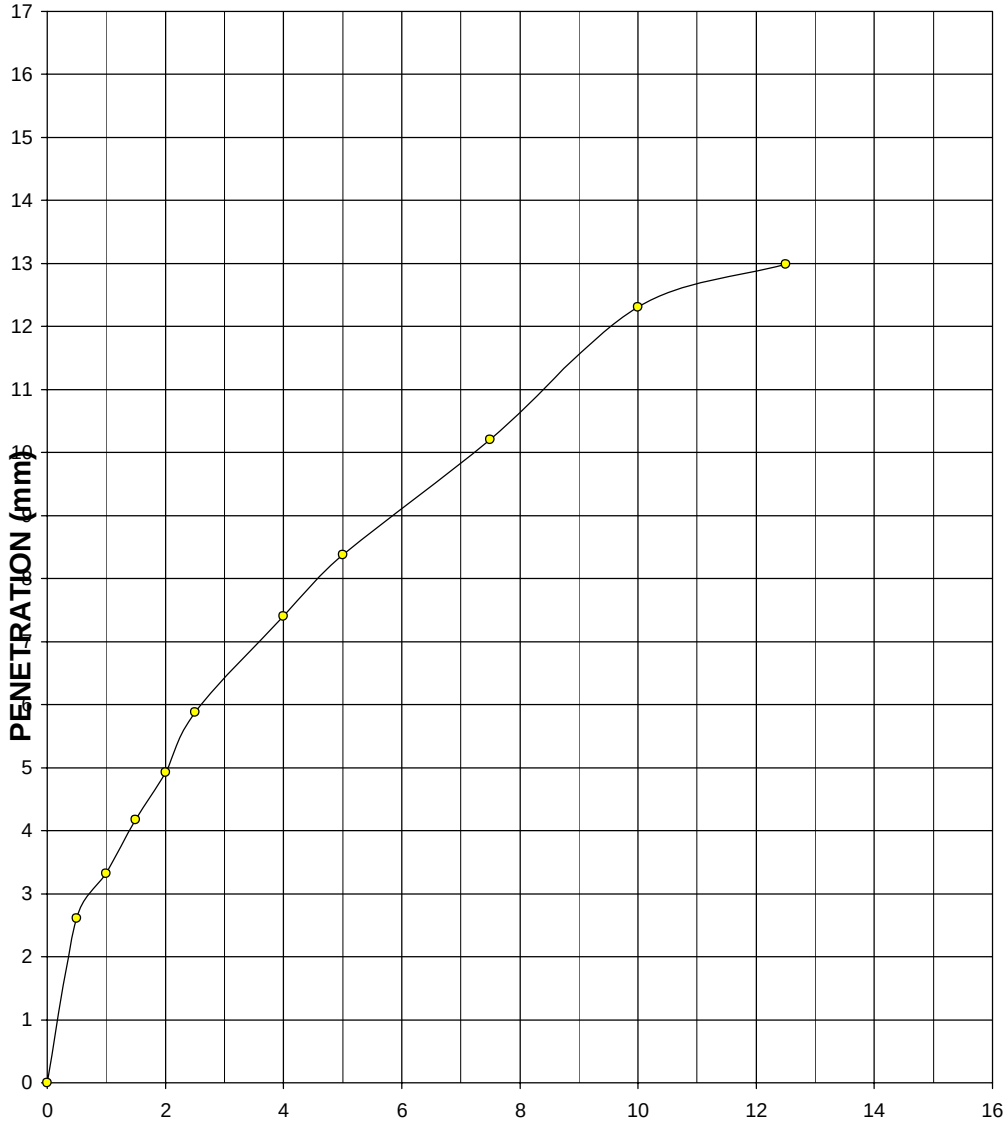


COMPACTION CURVE

Trial Pit No. - 2 Depth (m) 0.25 To 0.50

SHEET NO. 89

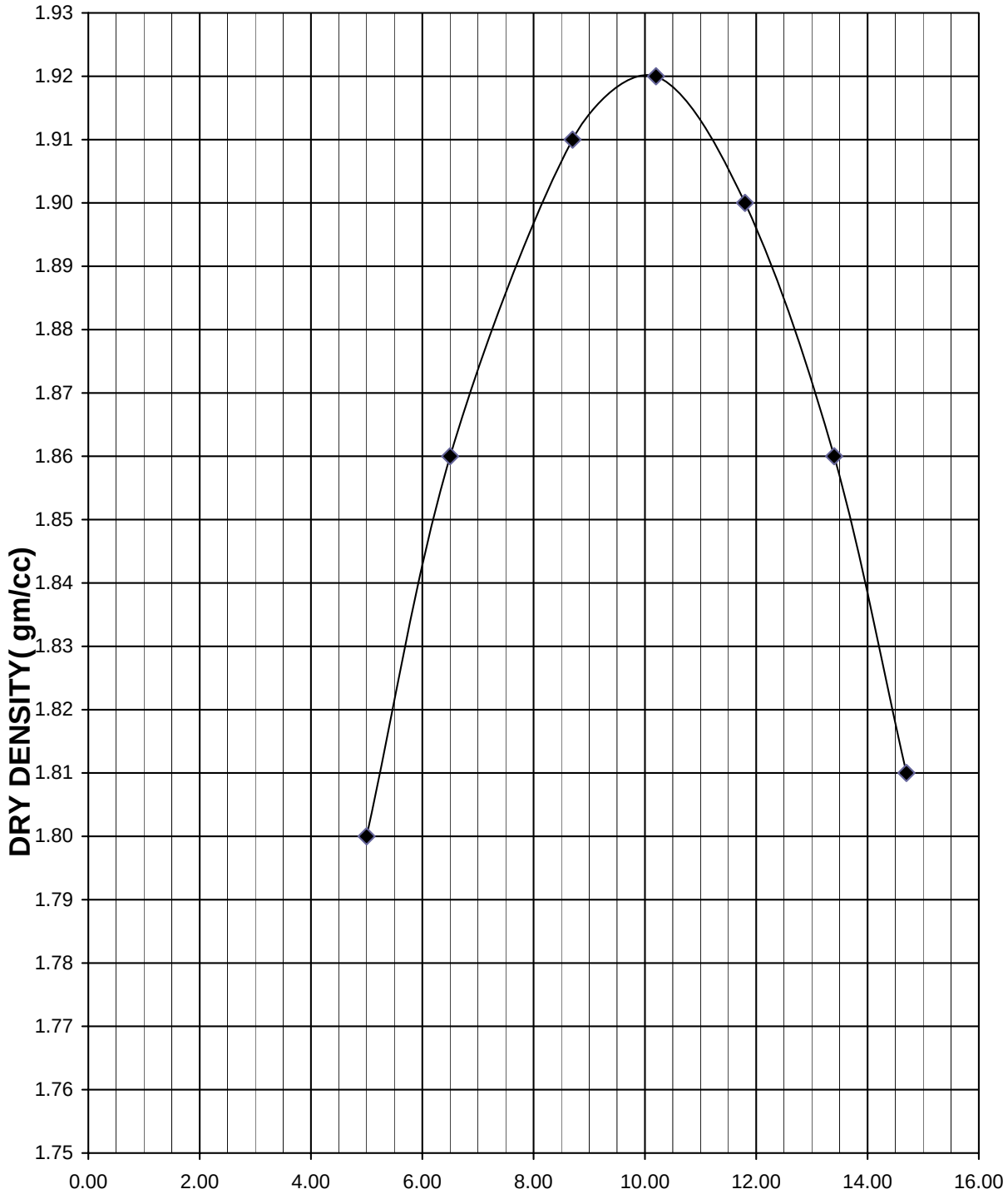
CORRECTEDLOAD ON PLUNGER IN Kg/cm2



CBR CURVE

Penetration, mm	CBR,%
2.5	8.4
5.0	8.0

TRIAL PIT NO. 2 Depth (mm) 0.25 to 0.50

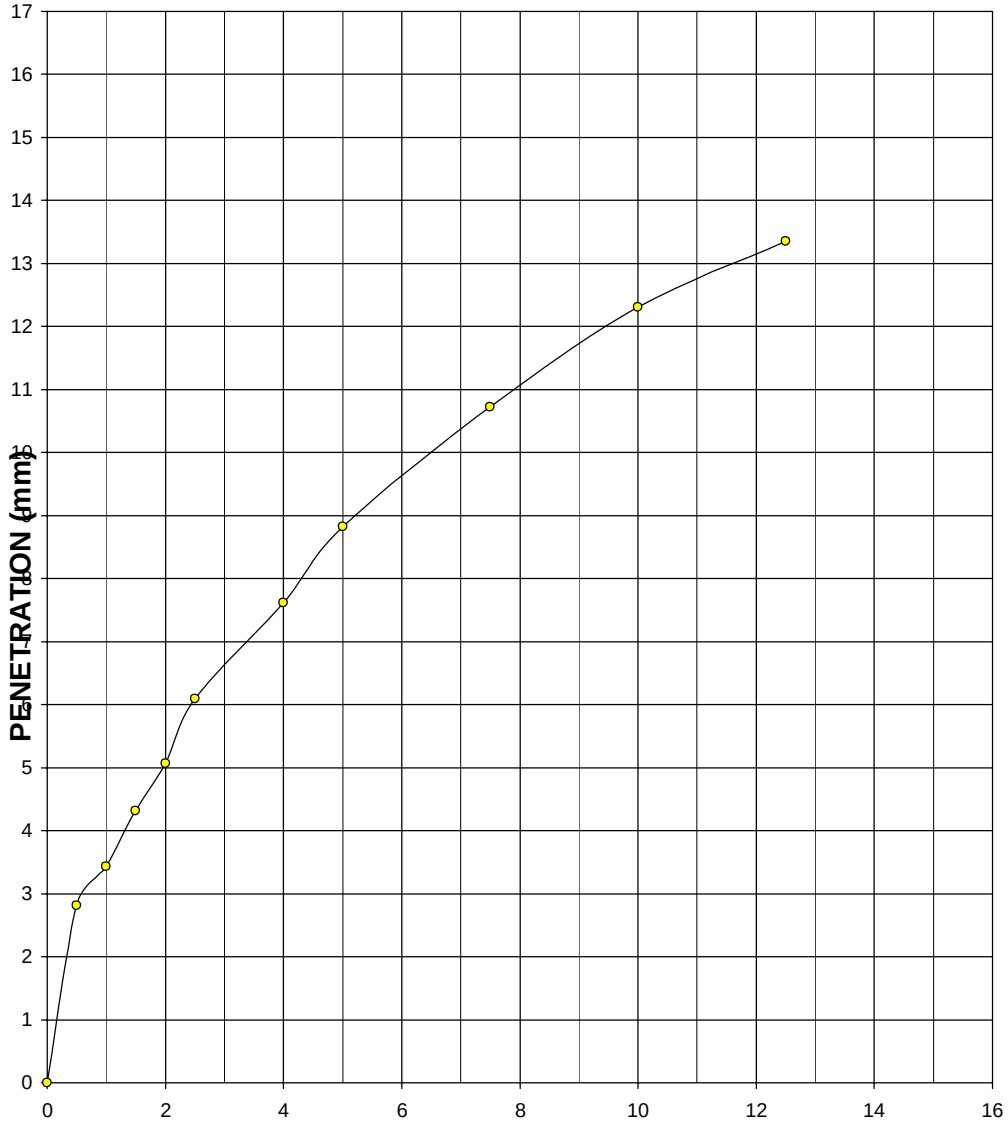


COMPACTION CURVE

Trial Pit No. - 2 Depth (m) 0.50 To 0.75

SHEET NO. 91

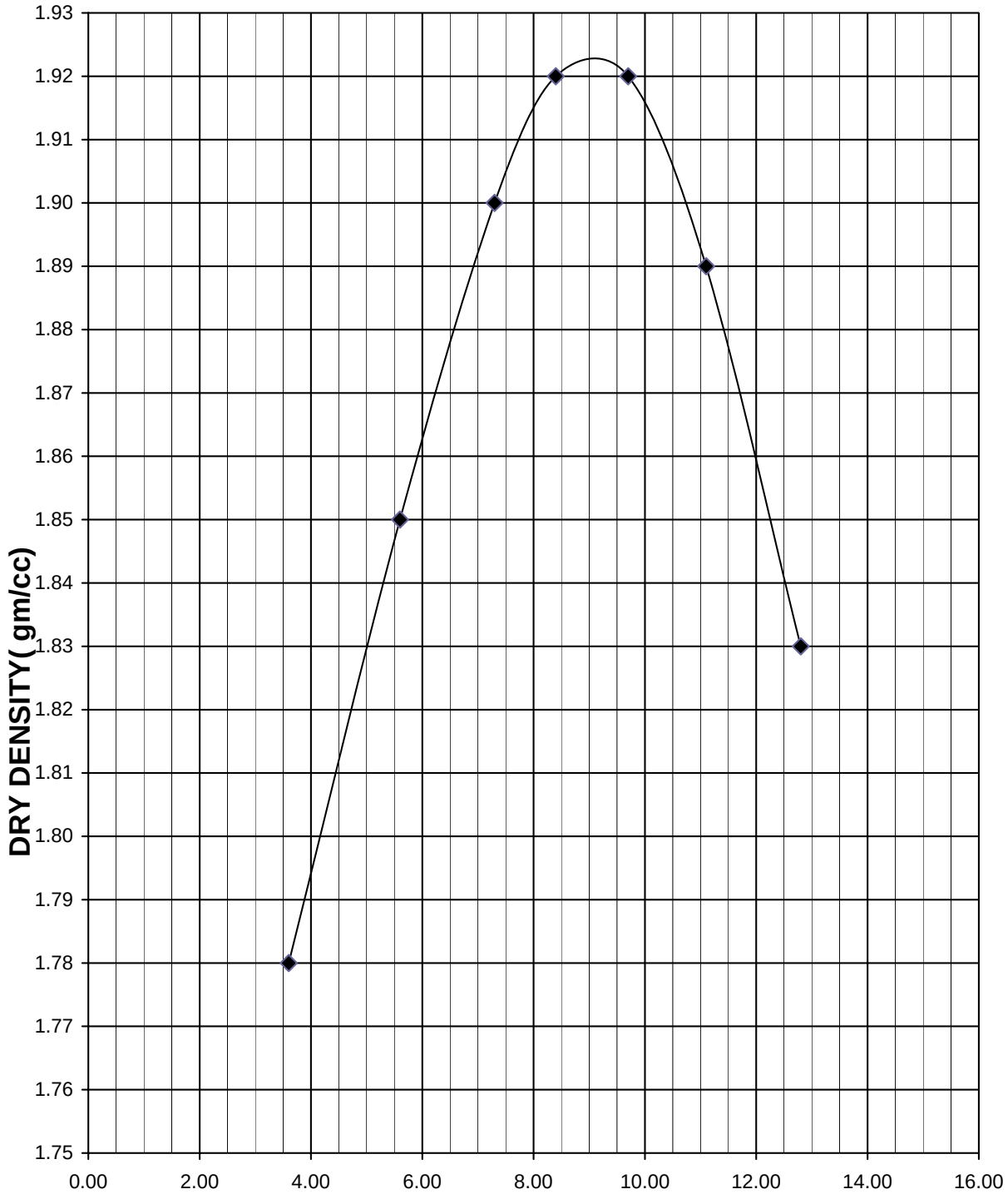
CORRECTEDLOAD ON PLUNGER IN Kg/cm2



CBR CURVE

Penetration, mm	CBR,%
2.5	8.7
5.0	8.4

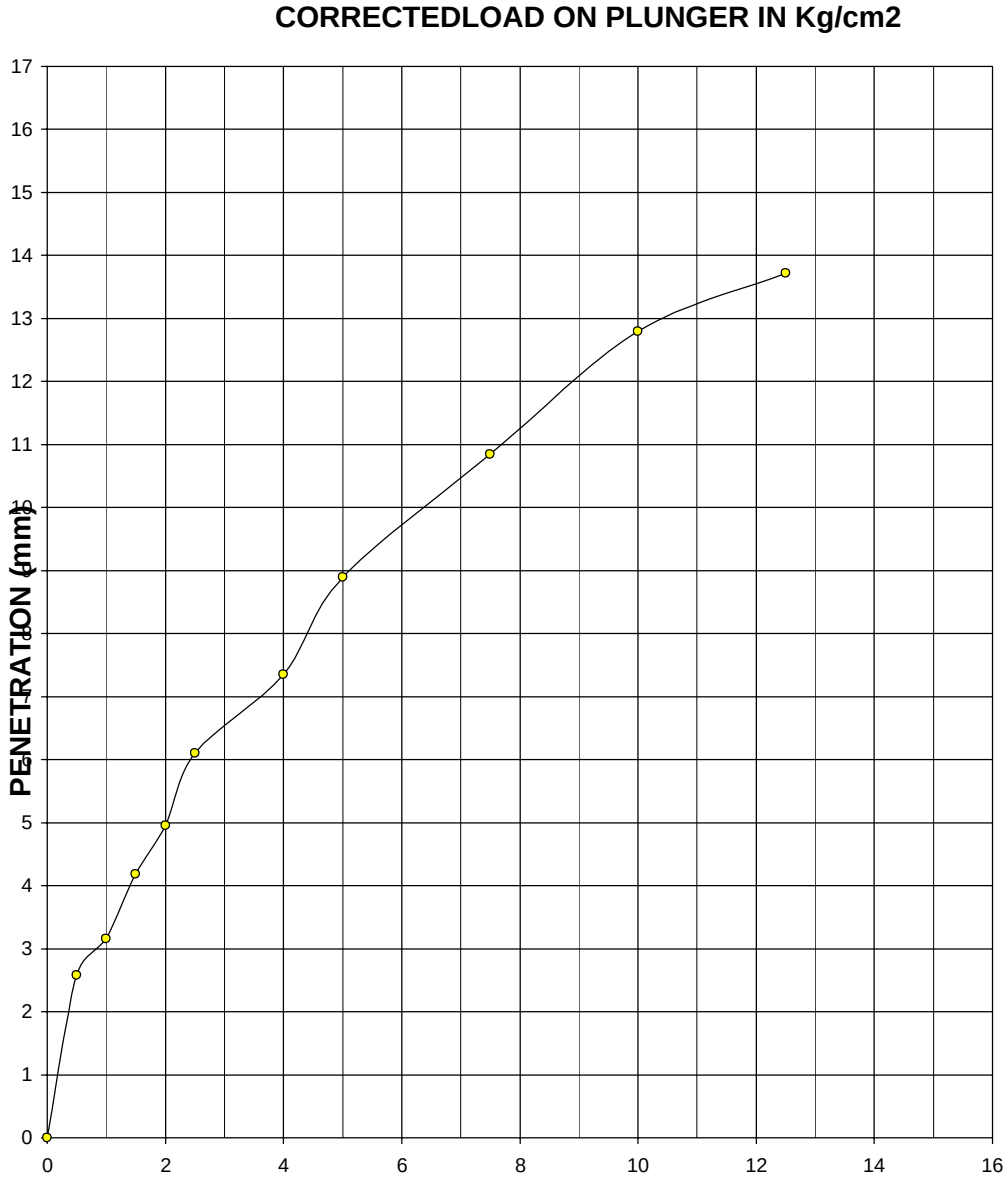
TRIAL PIT NO. 2 Depth (mm) 0.50-0.75



COMPACTION CURVE

Trial Pit No. - 2 Depth (m) 0.75 To 1.00

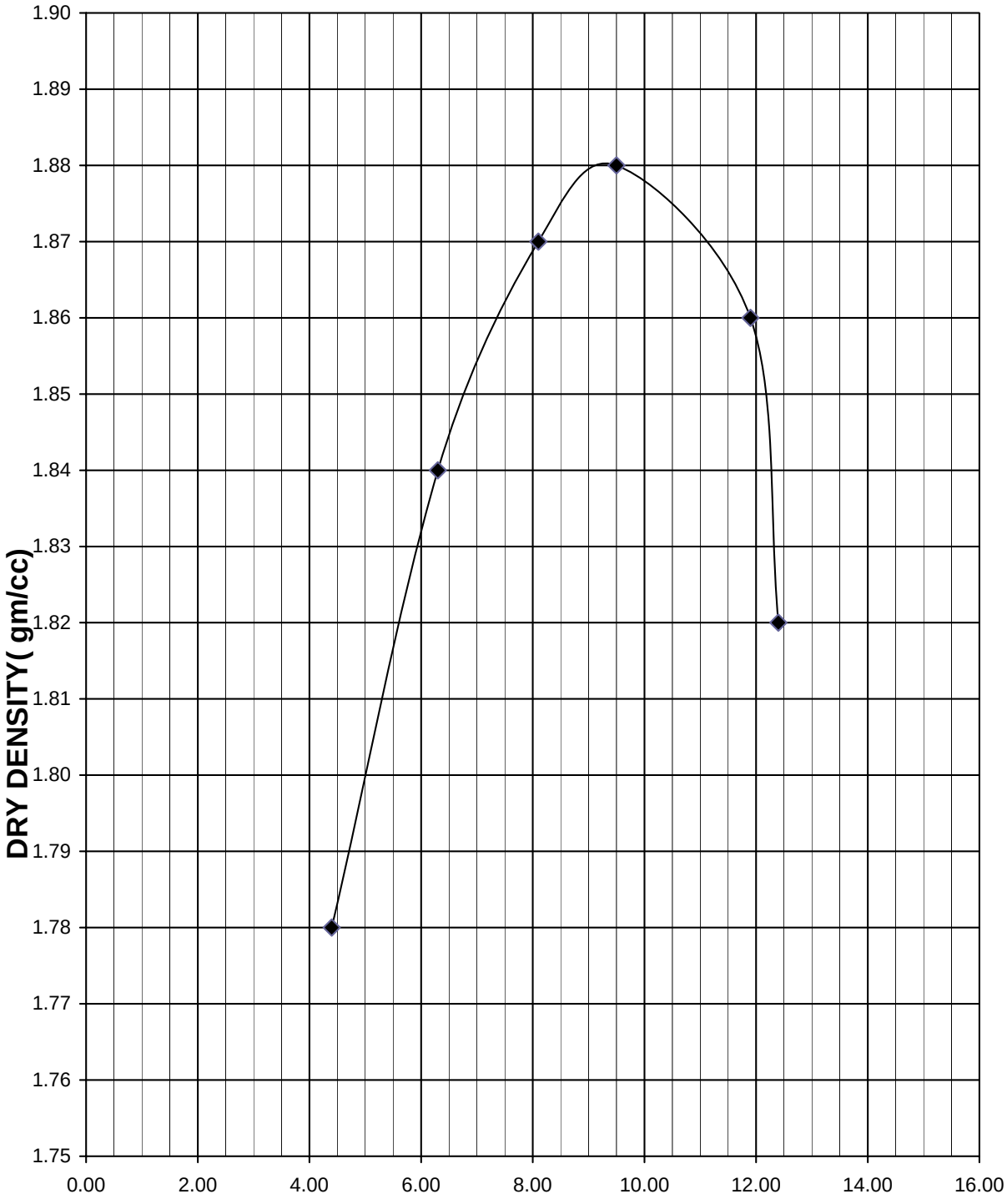
SHEET NO. 93



CBR CURVE

Penetration, mm	CBR,%
2.5	8.7
5.0	8.5

TRIAL PIT NO. 2 Depth (mm) 0.75 to 1.00

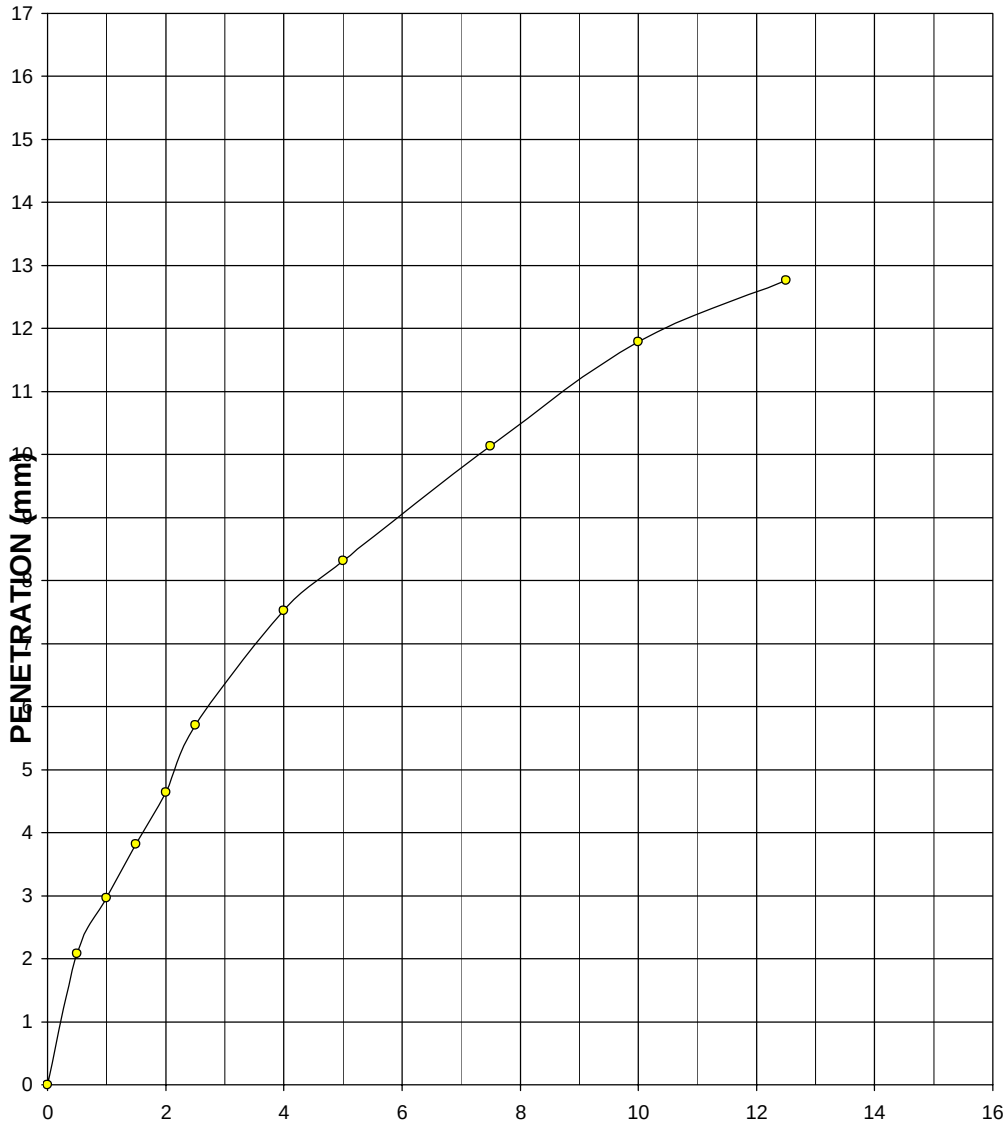


COMPACTION CURVE

Trial Pit No. - 3 Depth (m) GL. TO 0.25

SHEET NO. 95

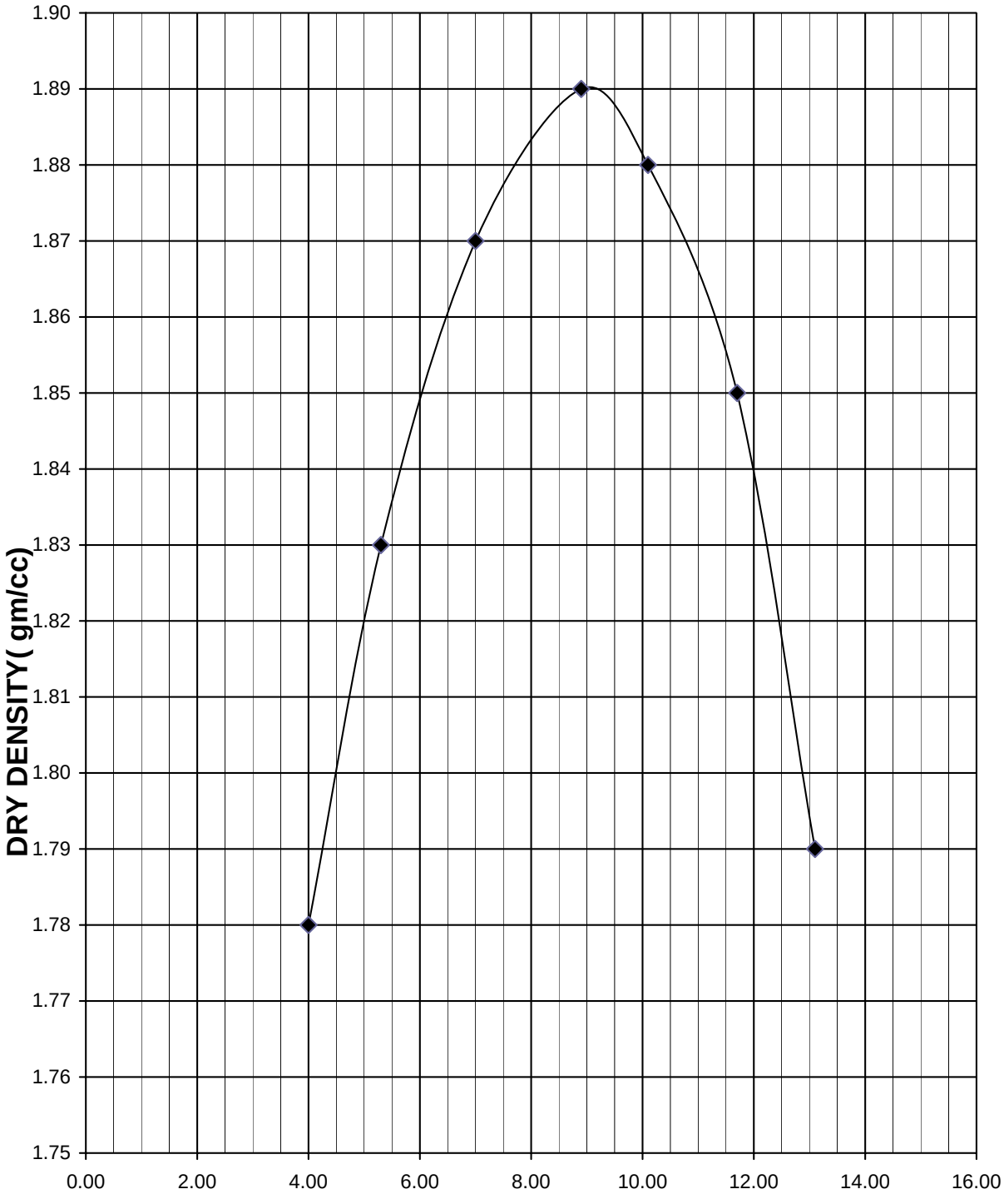
CORRECTEDLOAD ON PLUNGER IN Kg/cm2



CBR CURVE

Penetration, mm	CBR,%
2.5	8.2
5.0	7.9

TRIAL PIT NO. 3 Depth (mm) GL. to 0.25

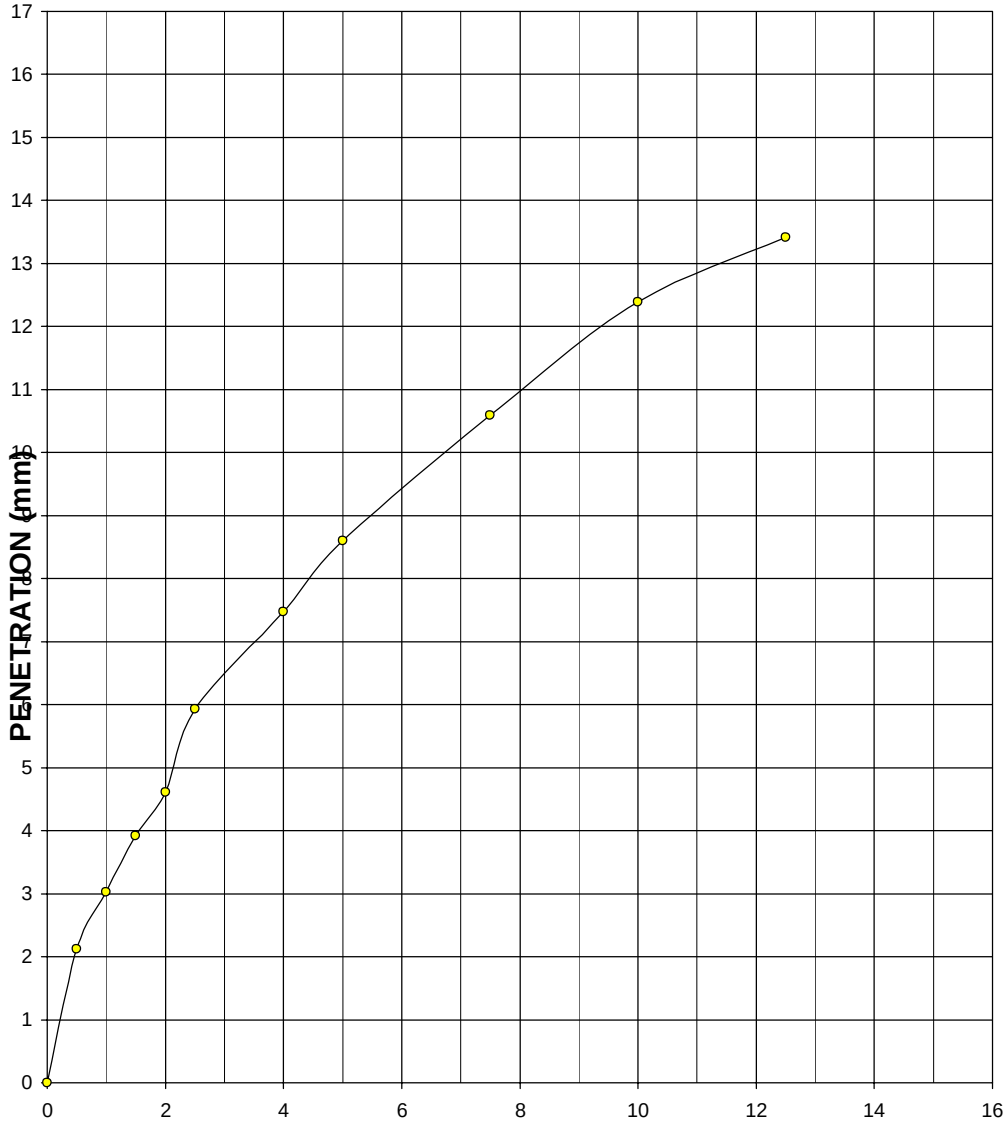


COMPACTION CURVE

Trial Pit No. - 3 Depth (m) 0.25 To 0.50

SHEET NO. 97

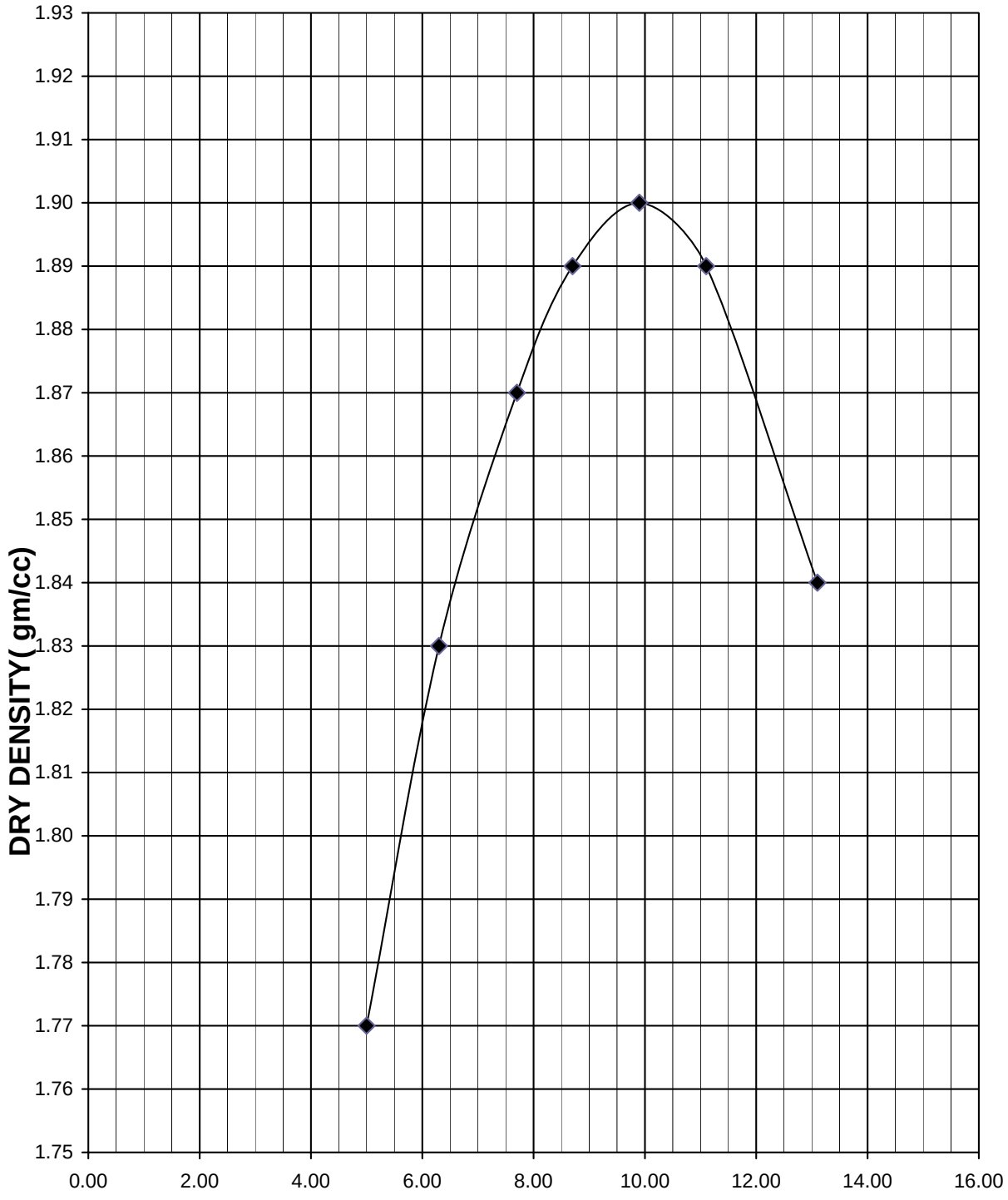
CORRECTEDLOAD ON PLUNGER IN Kg/cm2



CBR CURVE

Penetration, mm	CBR,%
2.5	8.5
5.0	8.2

TRIAL PIT NO. 3 Depth (mm) 0.25 to 0.50

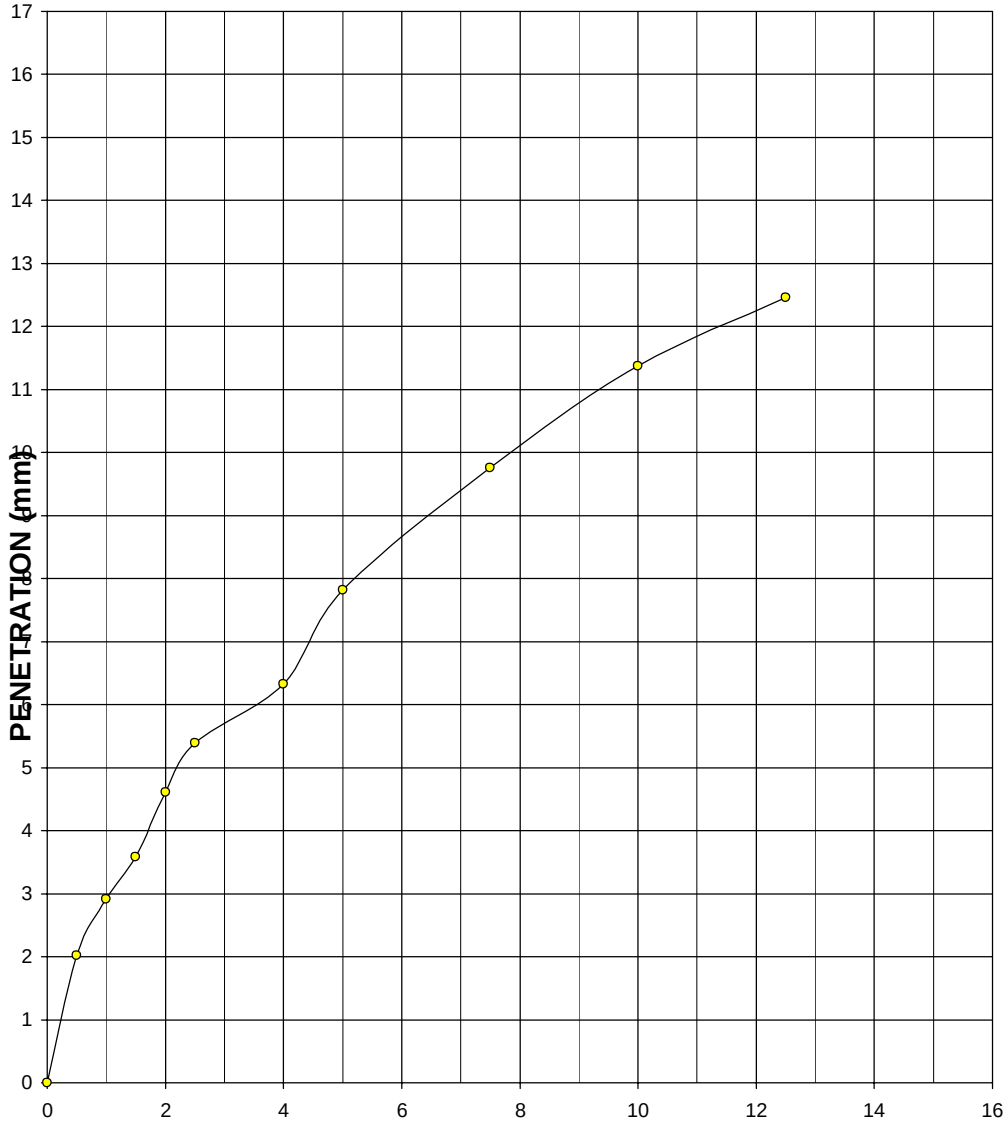


COMPACTION CURVE

Trial Pit No. - 3 Depth (m) 0.50 To 0.75

SHEET NO. 99

CORRECTEDLOAD ON PLUNGER IN Kg/cm2

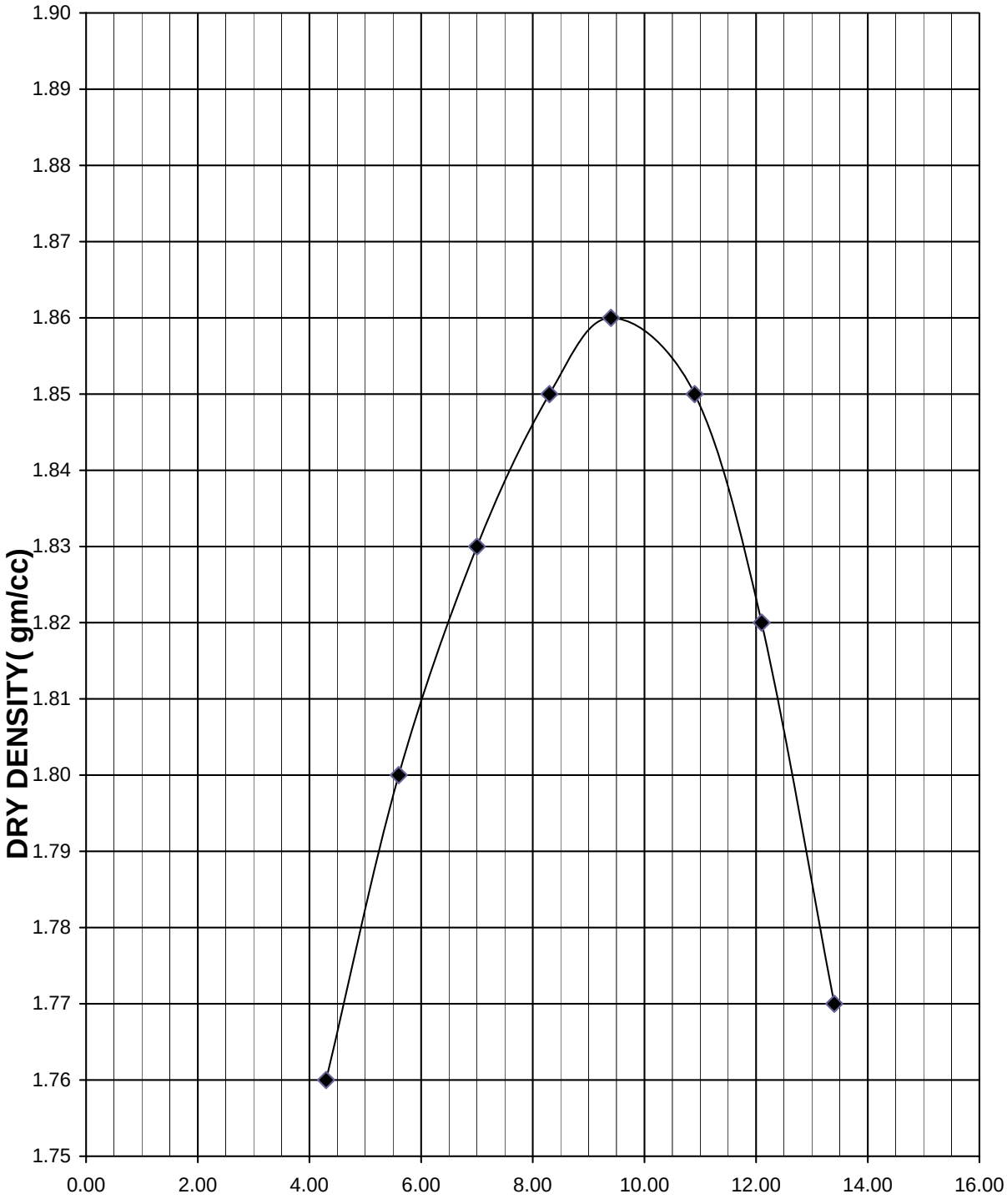


CBR CURVE

Penetration, mm	CBR,%
2.5	7.7
5.0	7.4

TRIAL PIT NO. 3 Depth (mm) 0.50-0.75

Sheet NO. 100

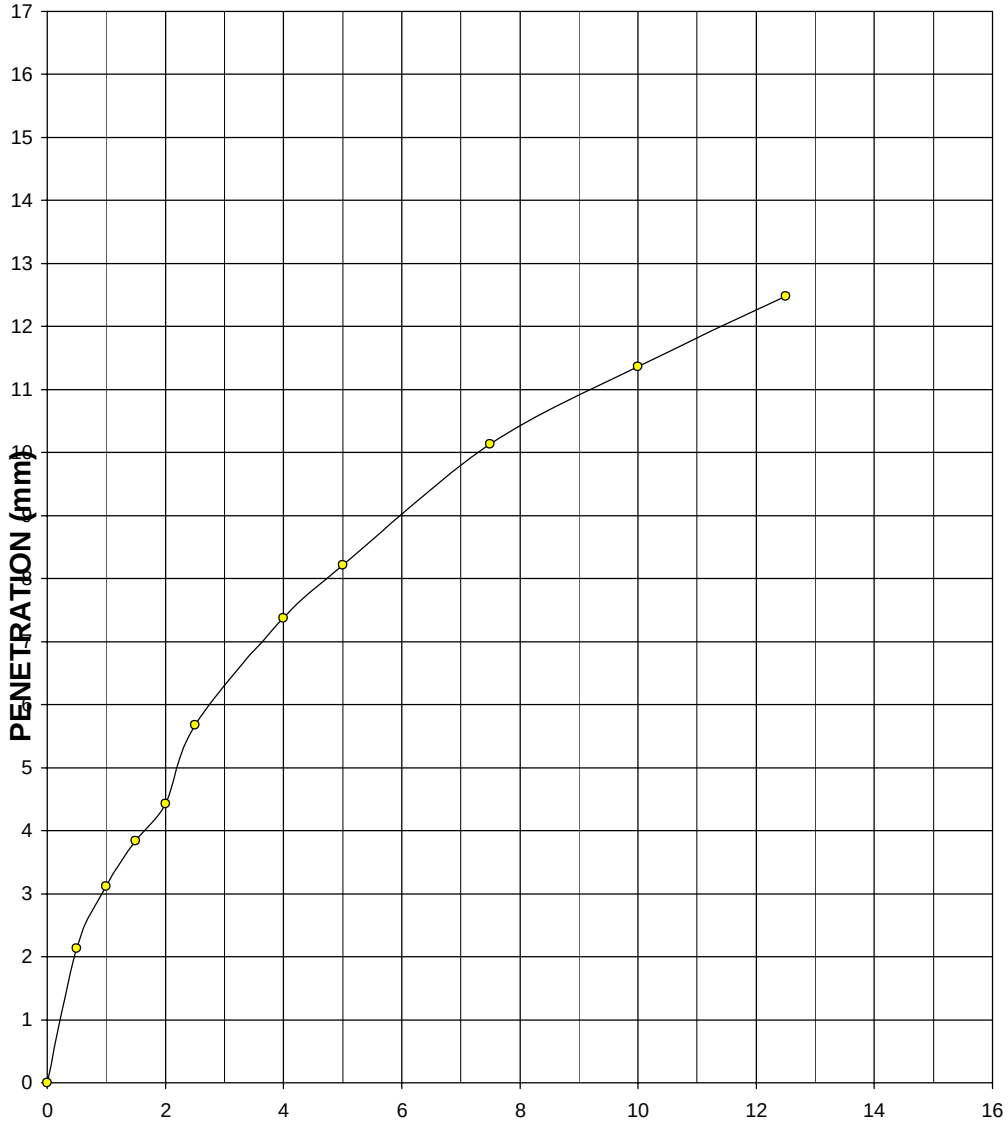


COMPACTION CURVE

Trial Pit No. - 3 Depth (m) 0.75 To 1.00

SHEET NO. 101

CORRECTEDLOAD ON PLUNGER IN Kg/cm2

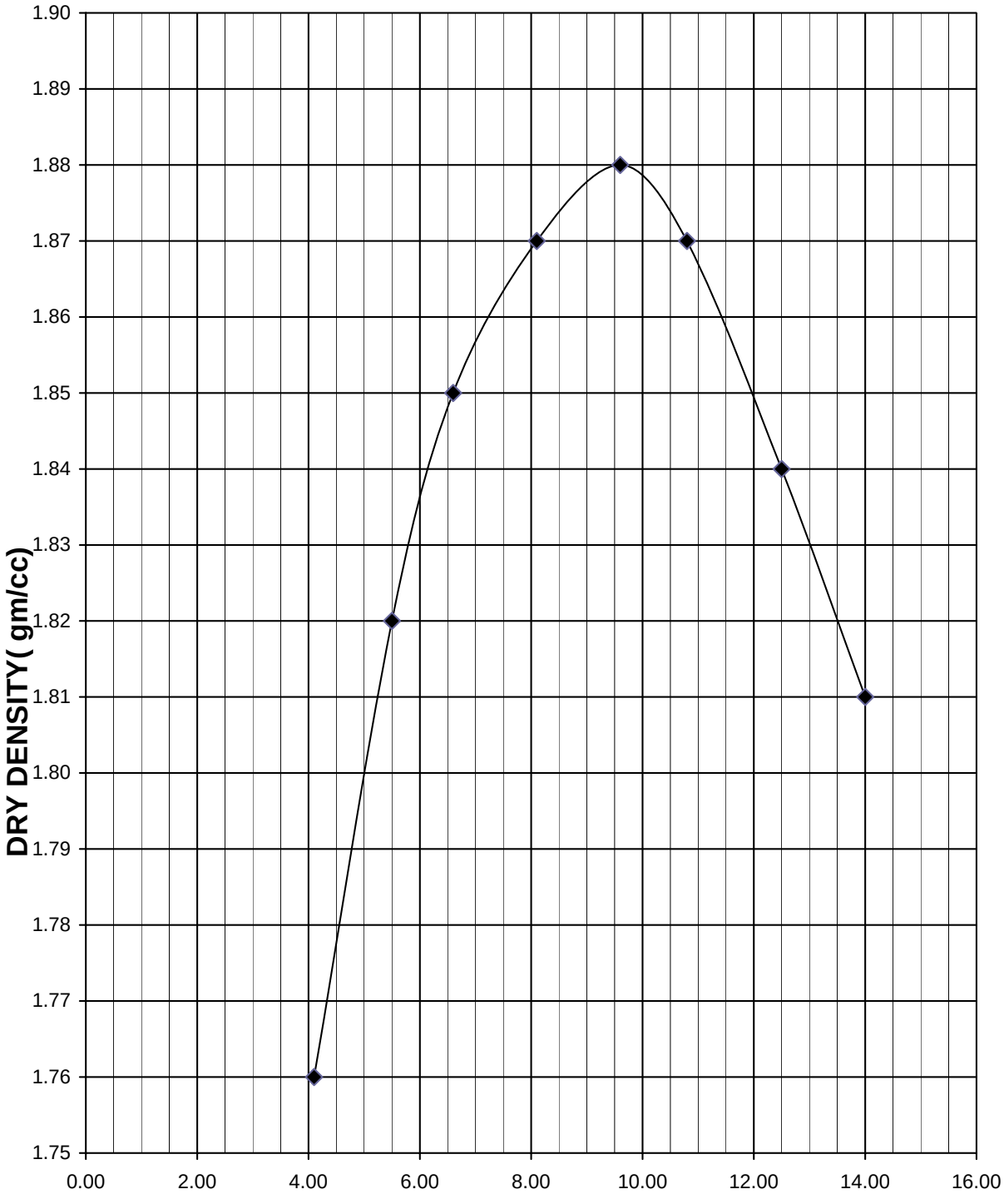


CBR CURVE

Penetration, mm	CBR,%
2.5	8.1
5.0	7.8

TRIAL PIT NO. 3 Depth (mm) 0.75 to 1.00

Sheet NO. 102

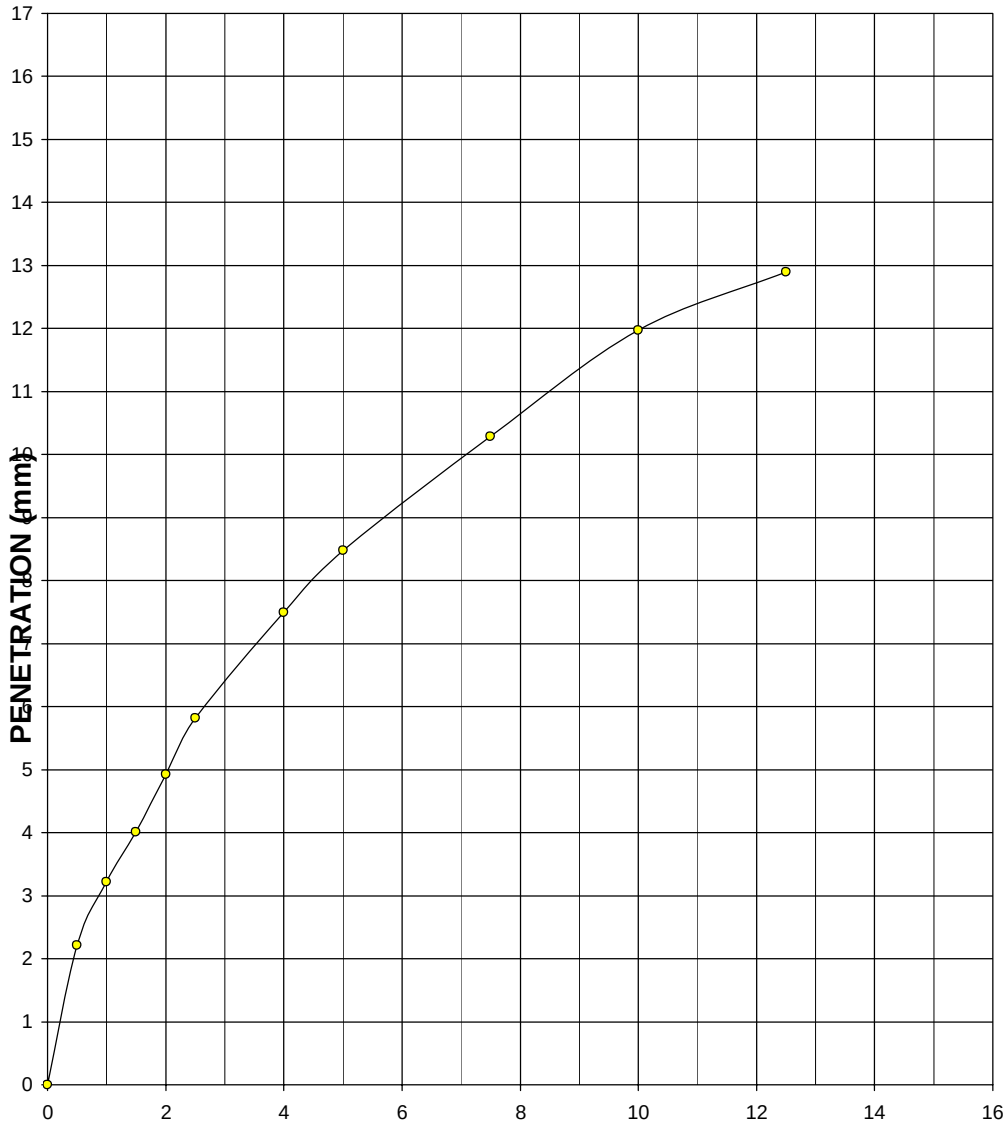


COMPACTION CURVE

Trial Pit No. - 4 Depth (m) GL. TO 0.25

SHEET NO. 103

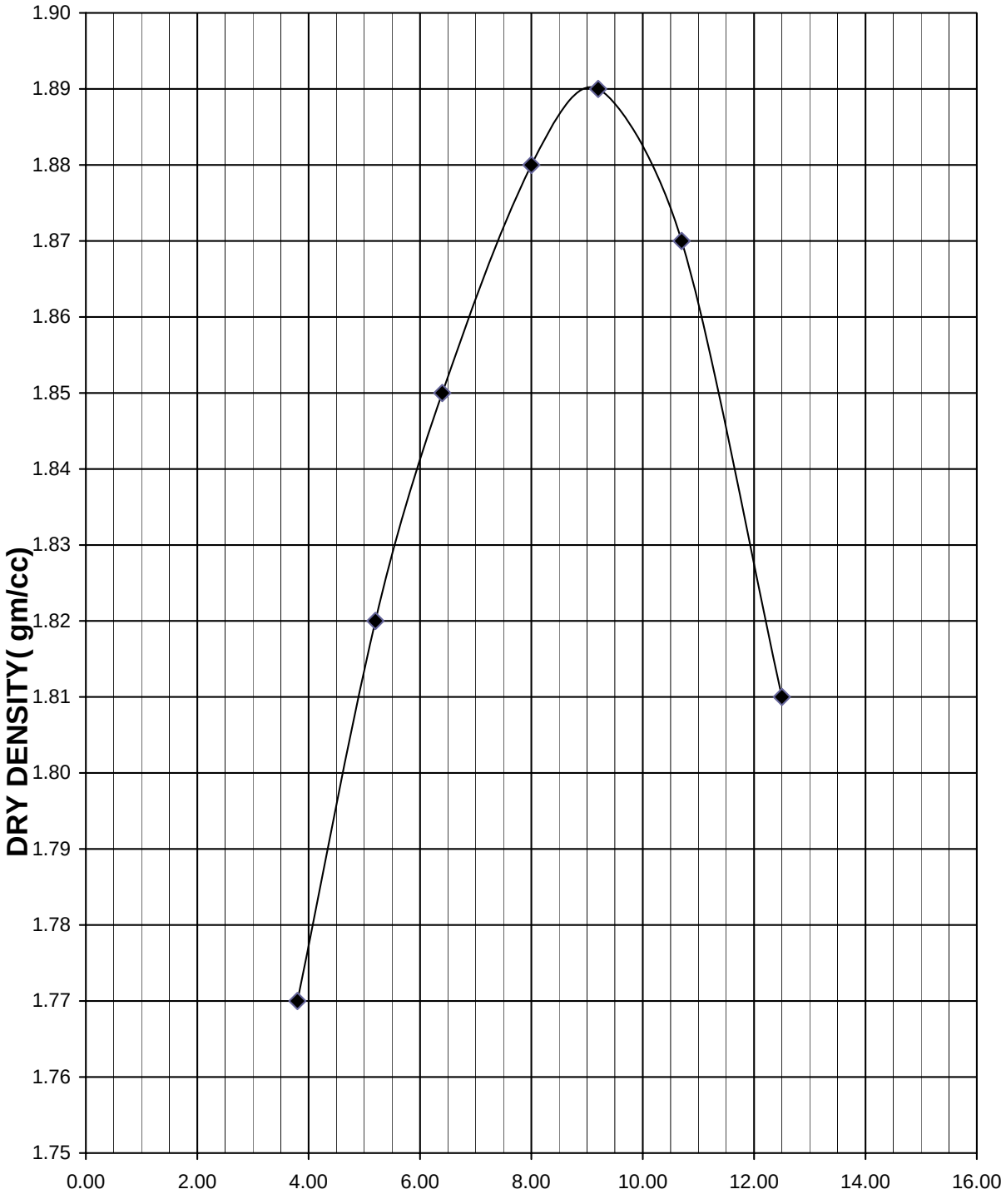
CORRECTEDLOAD ON PLUNGER IN Kg/cm2



CBR CURVE

Penetration, mm	CBR,%
2.5	8.3
5.0	8.1

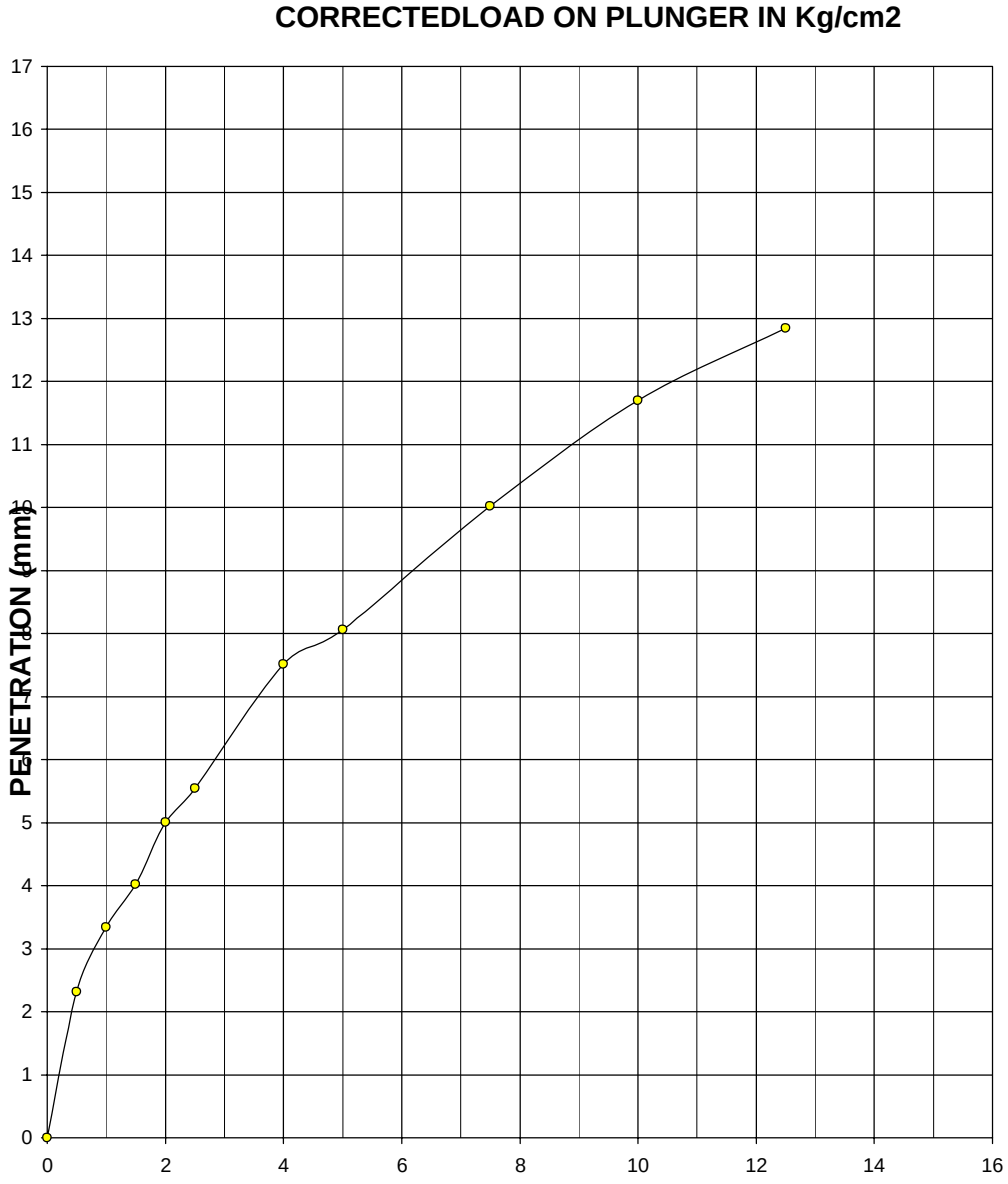
TRIAL PIT NO. 4 Depth (mm) GL. to 0.25



COMPACTION CURVE

Trial Pit No. - 4 Depth (m) 0.25 To 0.50

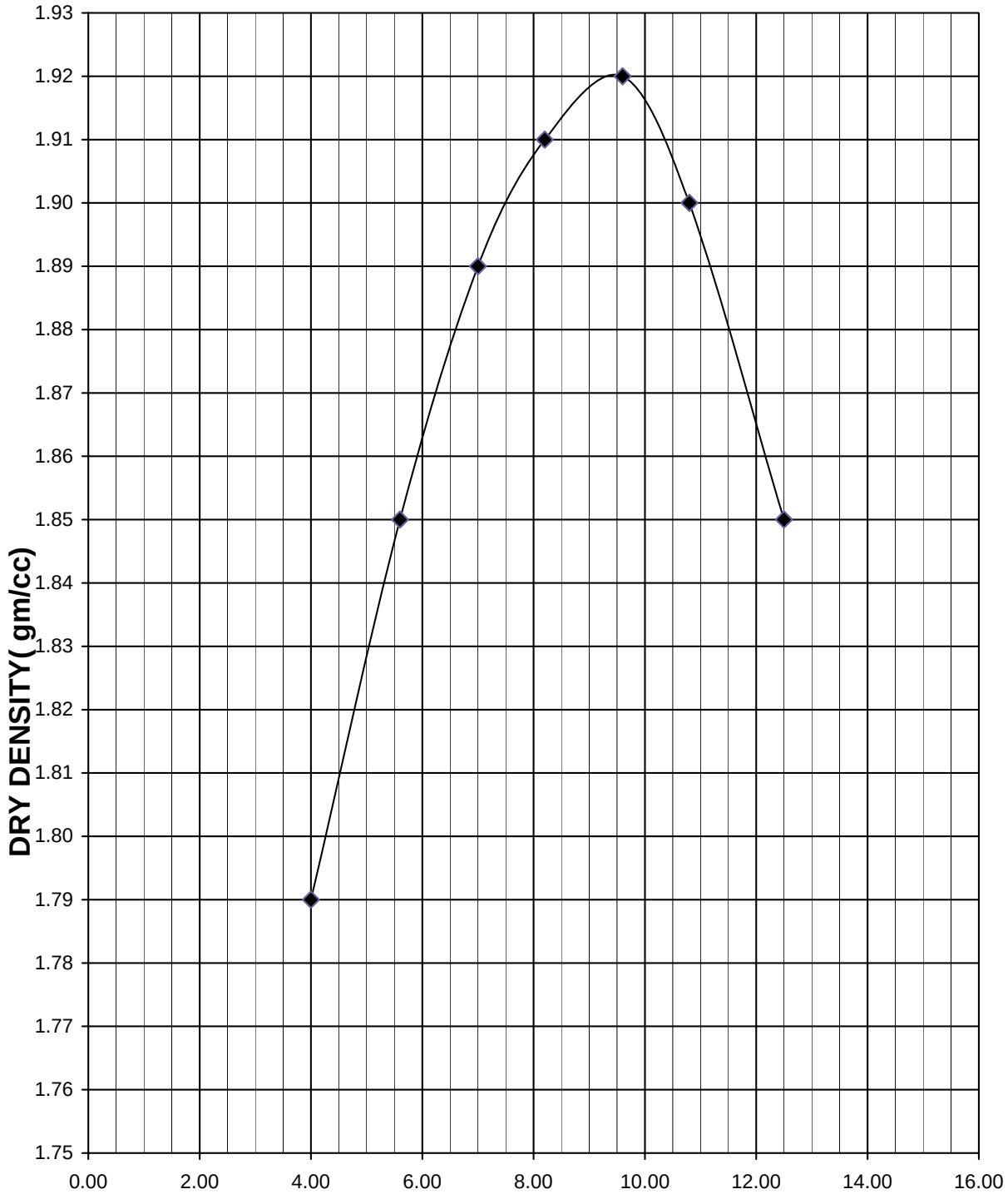
SHEET NO. 105



CBR CURVE

Penetration, mm	CBR,%
2.5	7.9
5.0	7.7

TRIAL PIT NO. 4 Depth (mm) 0.25 to 0.50

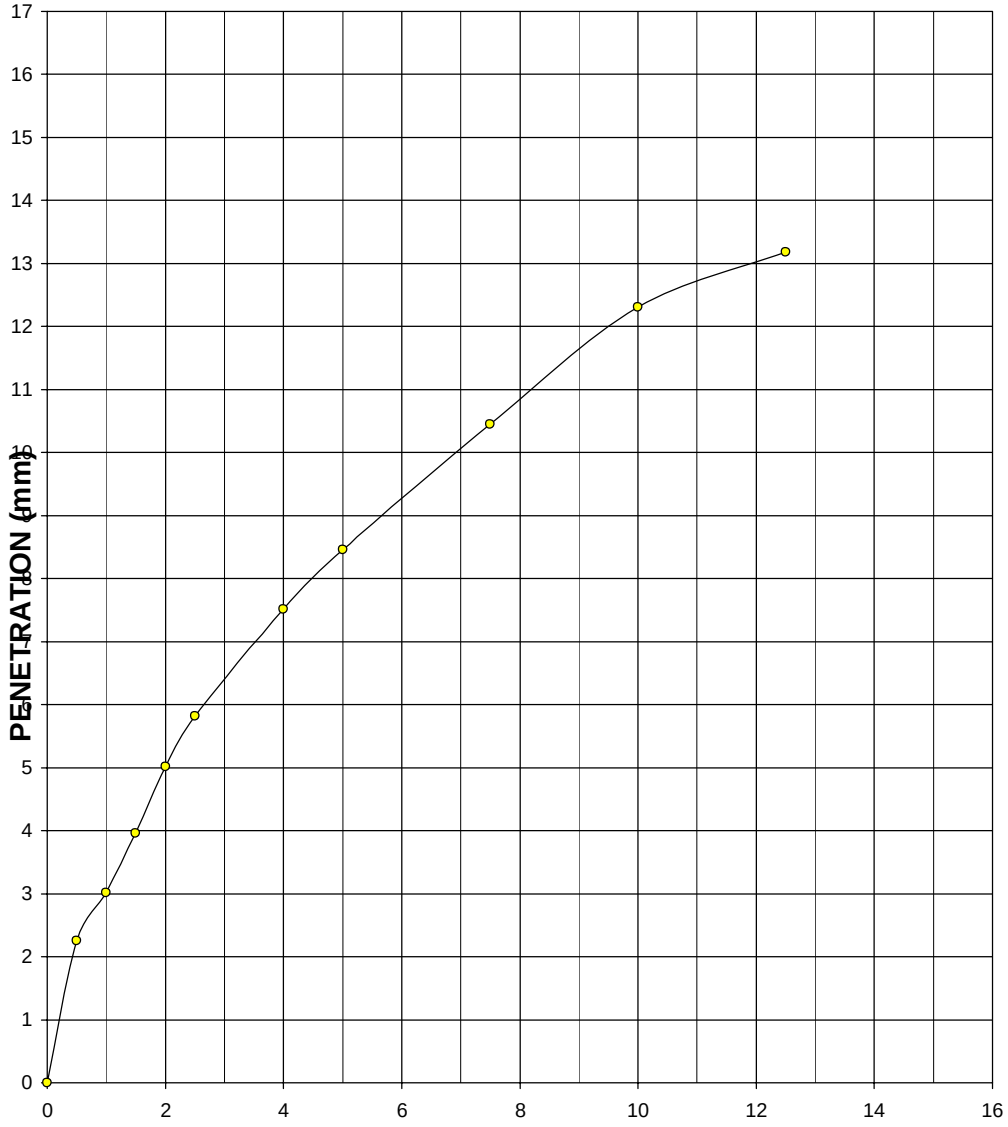


COMPACTION CURVE

Trial Pit No. - 4 Depth (m) 0.50 To 0.75

MAVERICK ENGINEERS	SHEET NO. 107

CORRECTEDLOAD ON PLUNGER IN Kg/cm2

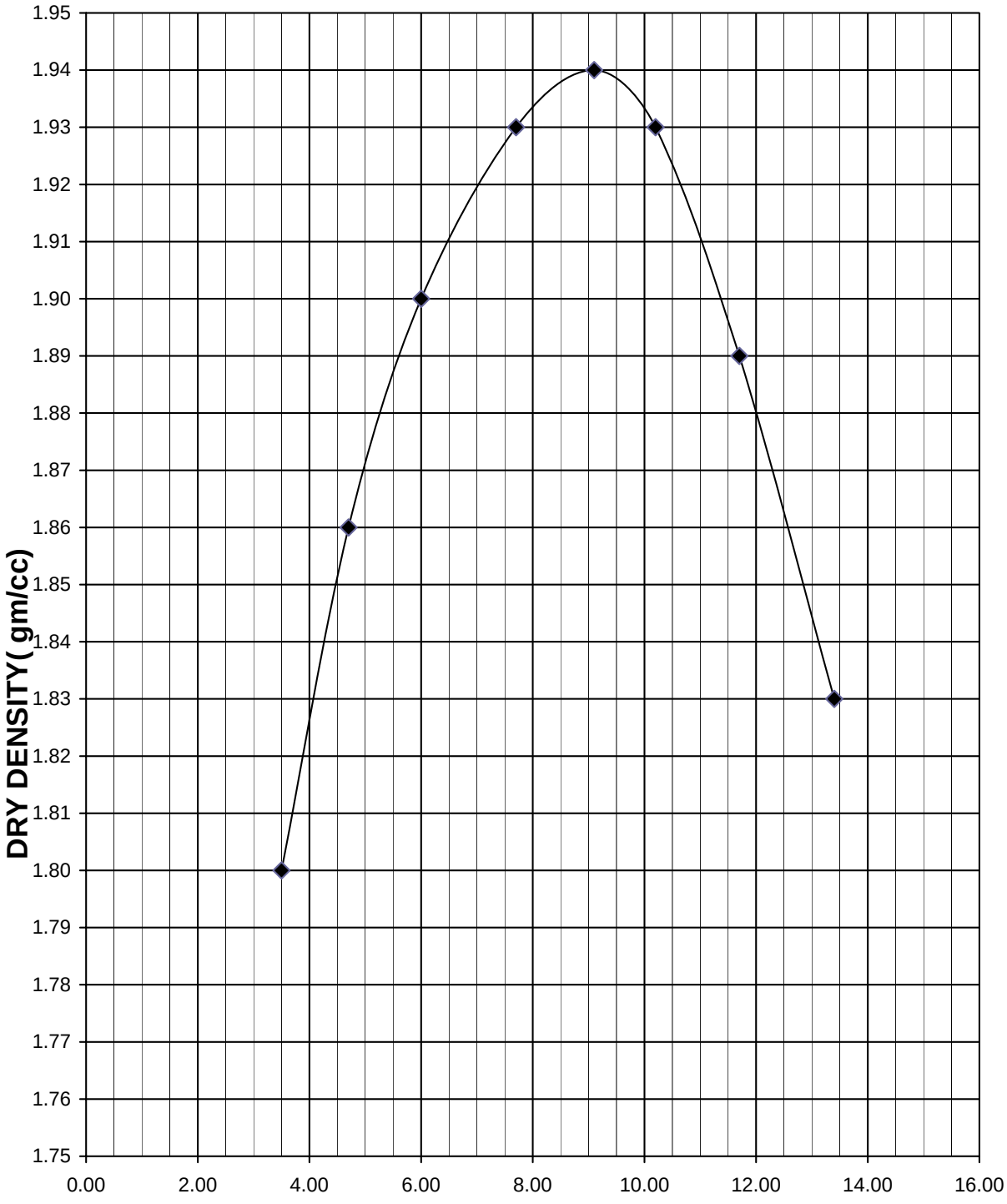


CBR CURVE

Penetration, mm	CBR,%
2.5	8.3
5.0	8.1

TRIAL PIT NO. 4 Depth (mm) 0.50-0.75

Sheet NO. 108

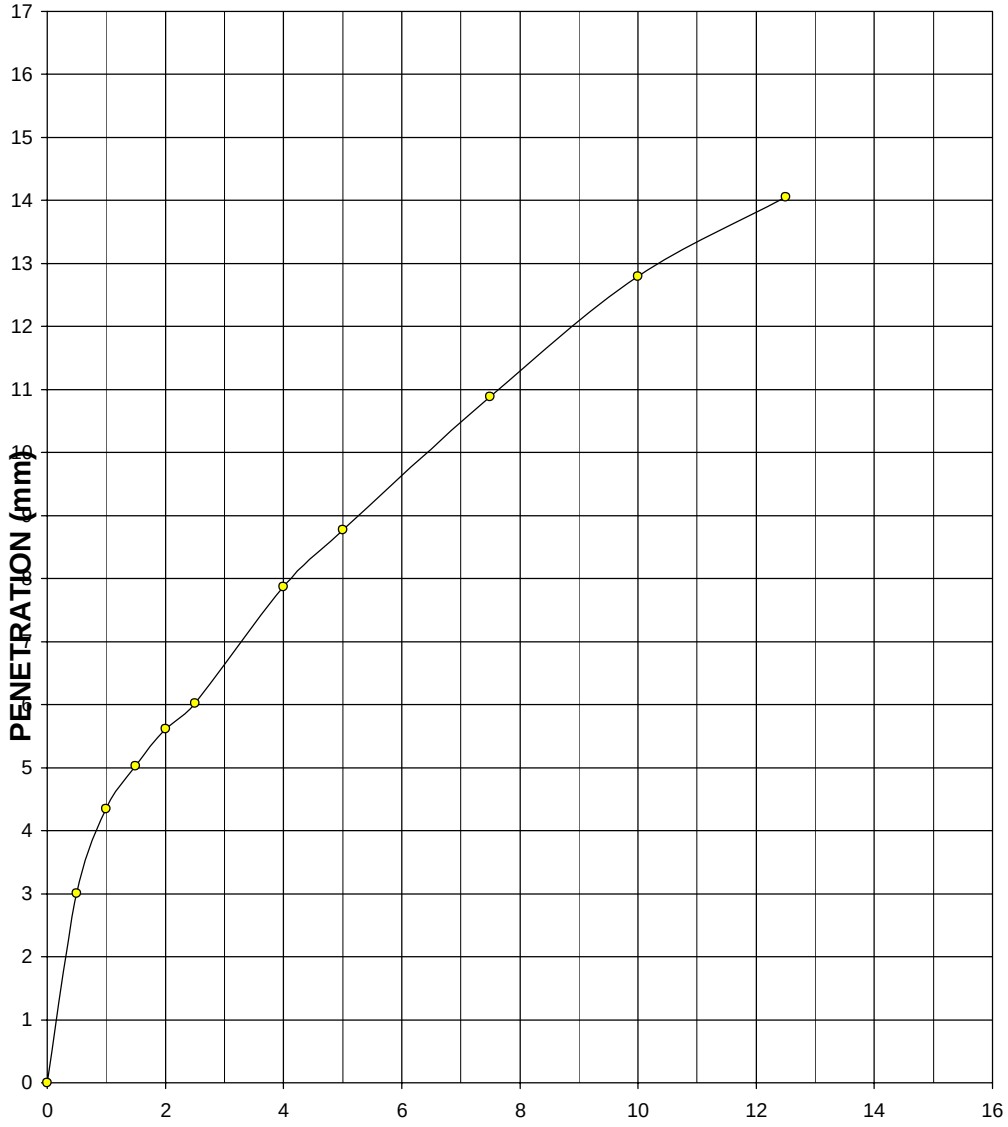


COMPACTION CURVE

Trial Pit No. - 4 Depth (m) 0.75 To 1.00

SHEET NO. 109

CORRECTEDLOAD ON PLUNGER IN Kg/cm2

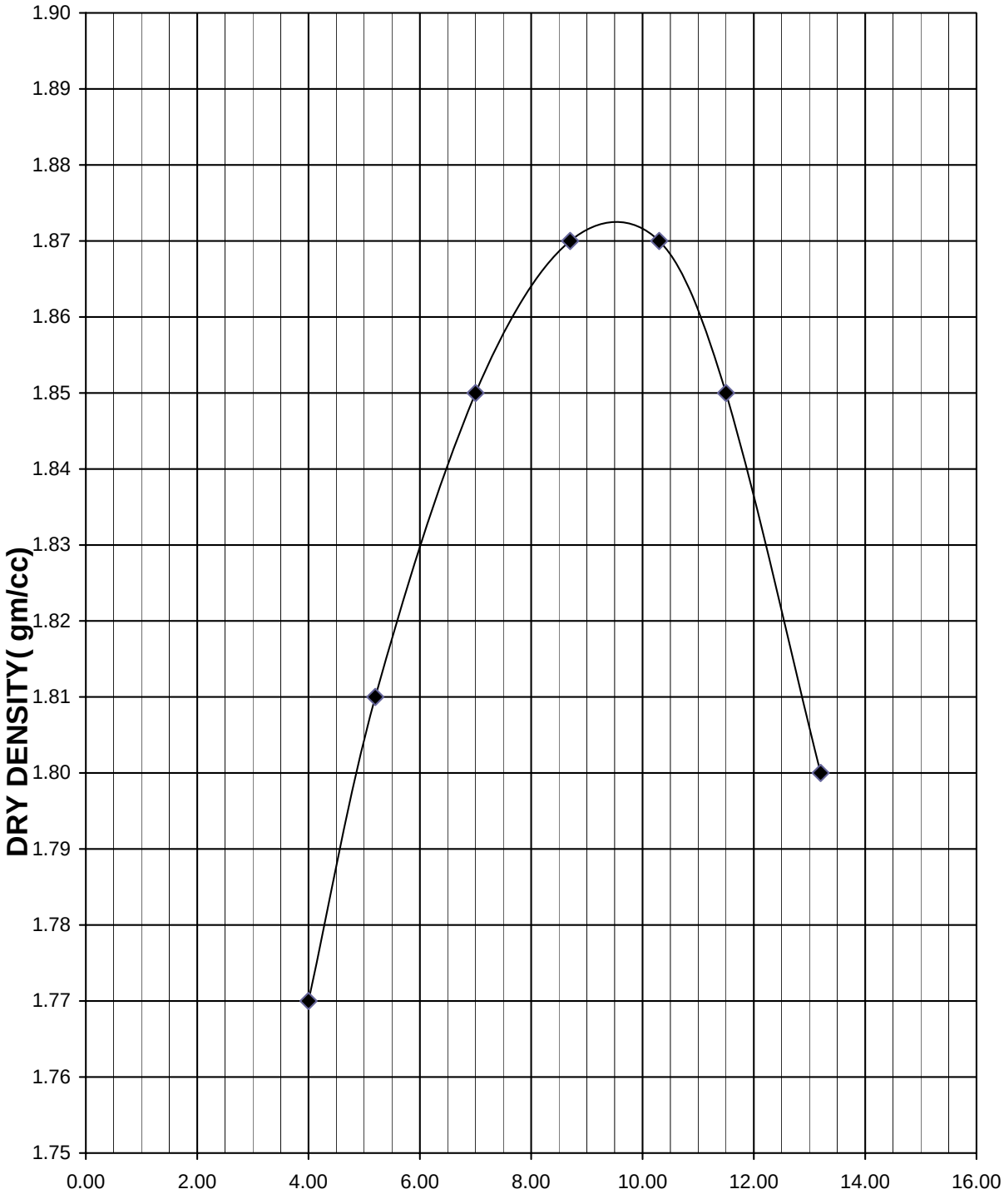


CBR CURVE

Penetration, mm	CBR,%
2.5	8.6
5.0	8.4

TRIAL PIT NO. 4 Depth (mm) 0.75 to 1.00

Sheet NO. 110

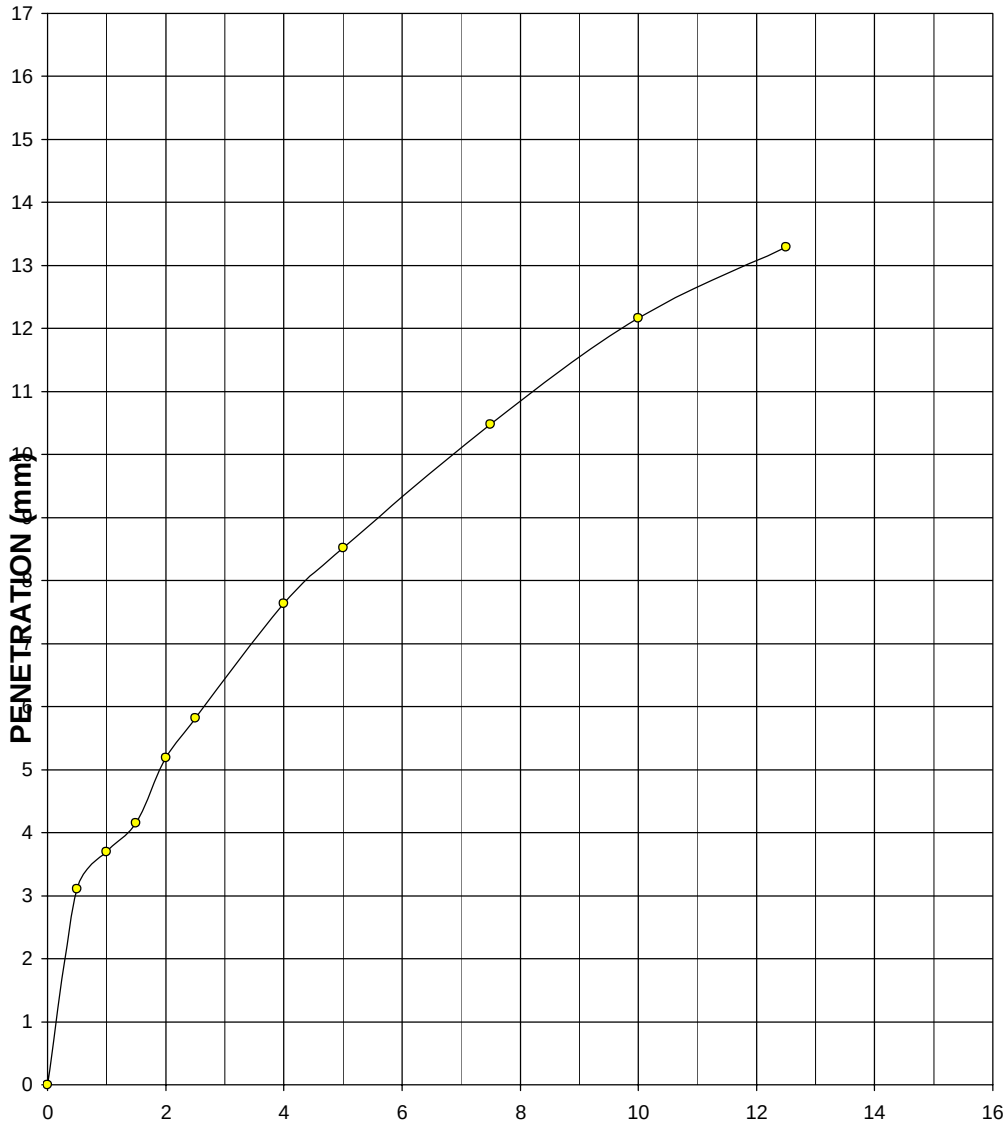


COMPACTION CURVE

Trial Pit No. - 5 Depth (m) GL. TO 0.25

SHEET NO. 111

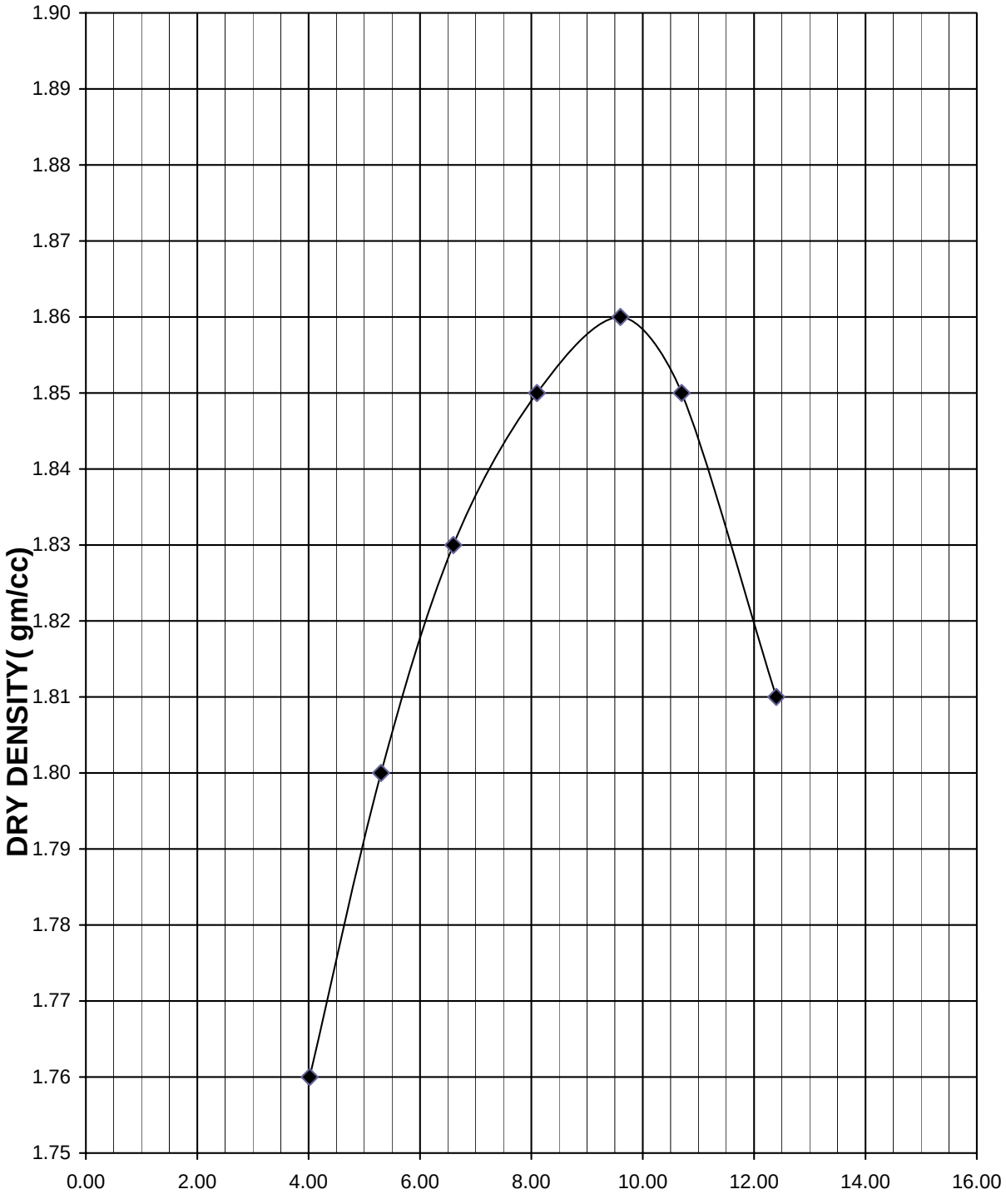
CORRECTEDLOAD ON PLUNGER IN Kg/cm2



CBR CURVE

Penetration, mm	CBR,%
2.5	8.3
5.0	8.1

TRIAL PIT NO. 5 Depth (mm) GL. to 0.25

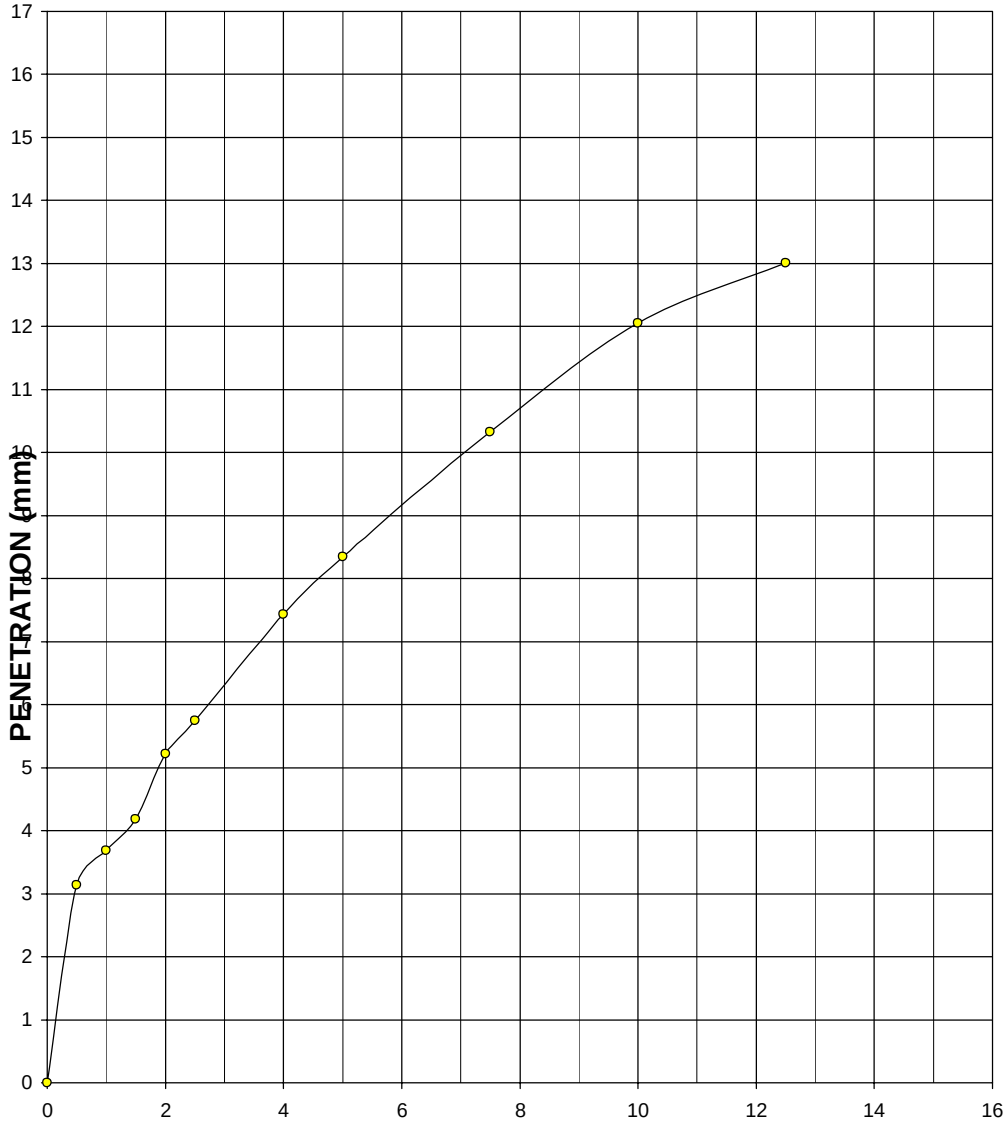


COMPACTION CURVE

Trial Pit No. - 5 Depth (m) 0.25 To 0.50

SHEET NO. 113

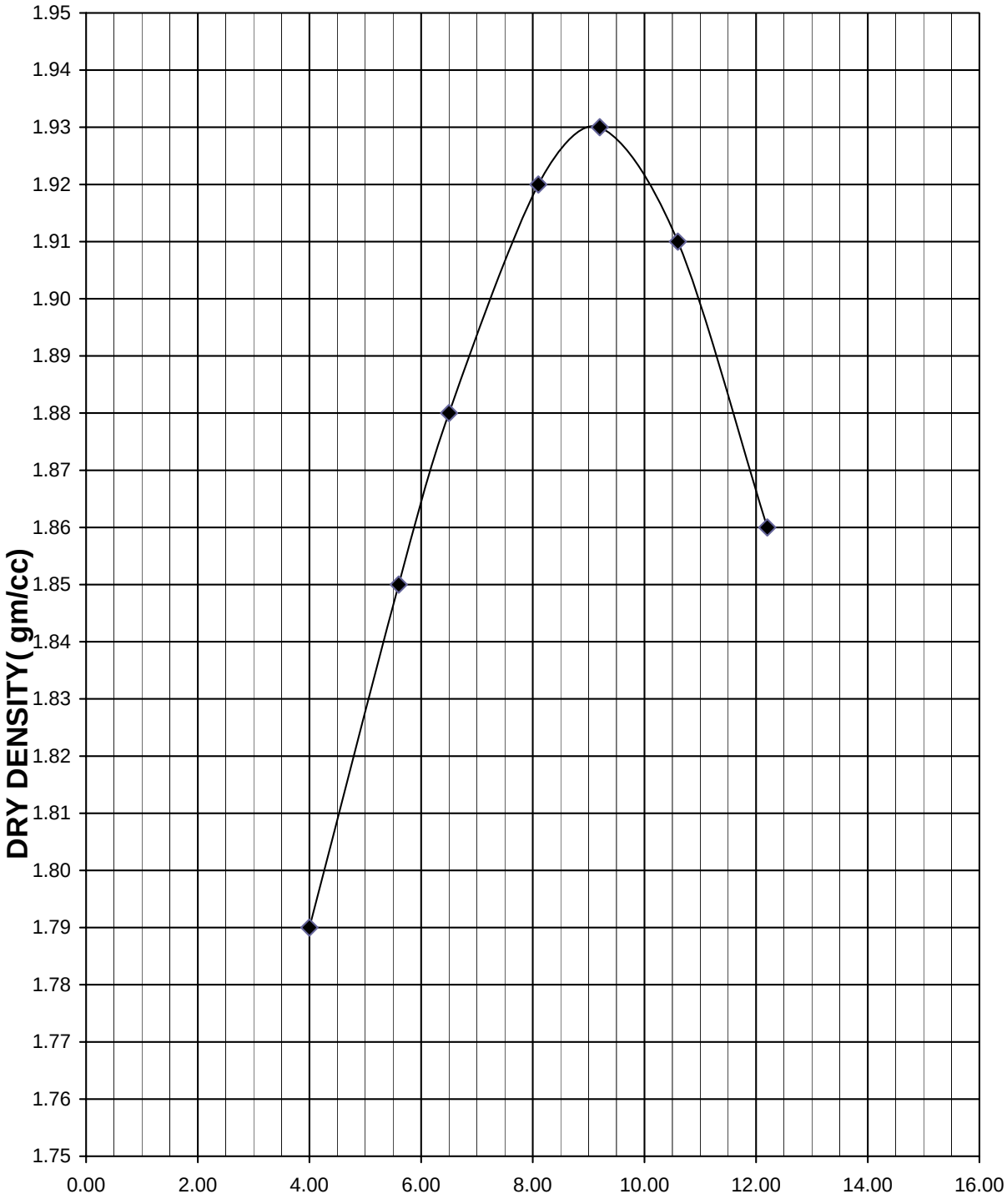
CORRECTEDLOAD ON PLUNGER IN Kg/cm2



CBR CURVE

Penetration, mm	CBR,%
2.5	8.2
5.0	8.0

TRIAL PIT NO. 5 Depth (mm) 0.25 to 0.50

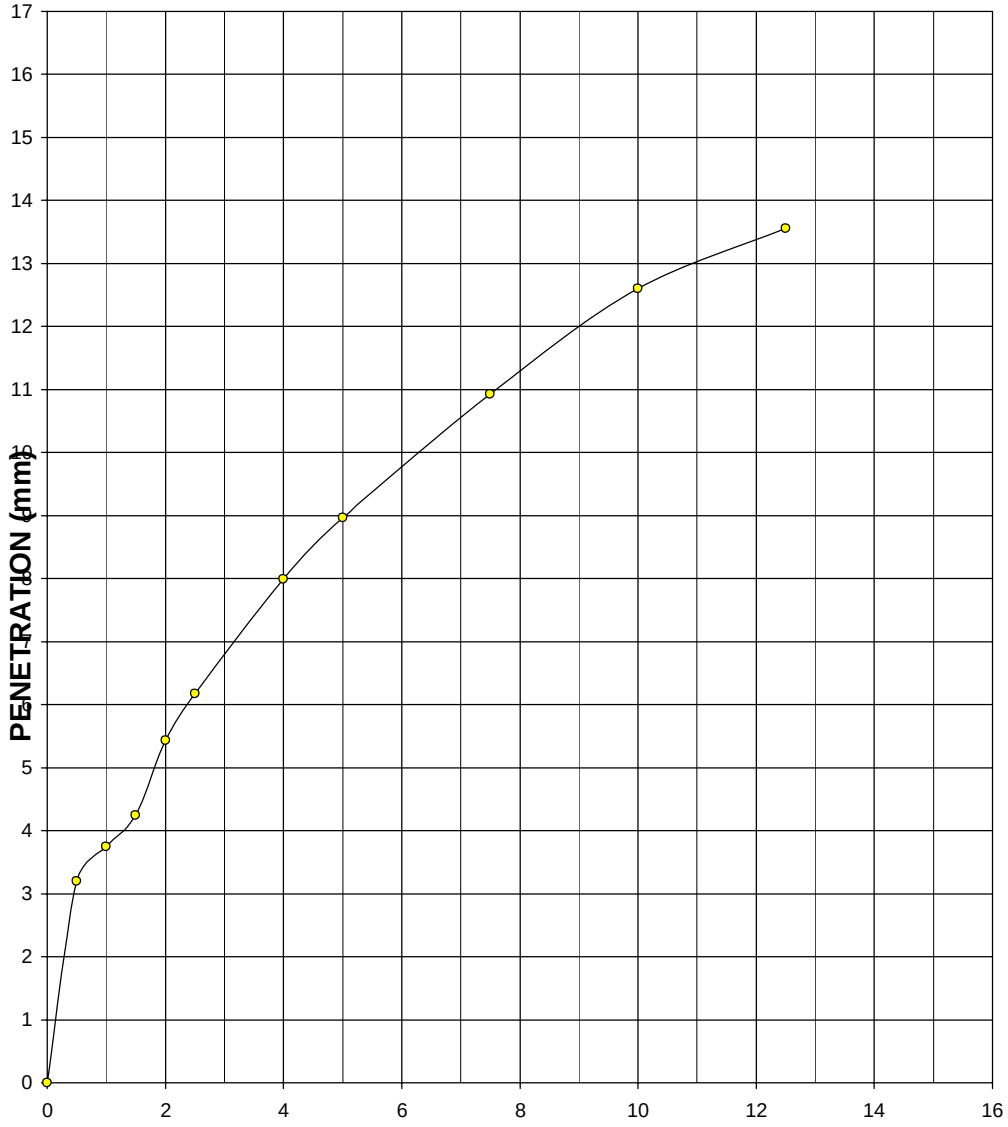


COMPACTION CURVE

Trial Pit No. - 5 Depth (m) 0.50 To 0.75

MAVERICK ENGINEERS	SHEET NO. 115

CORRECTEDLOAD ON PLUNGER IN Kg/cm2

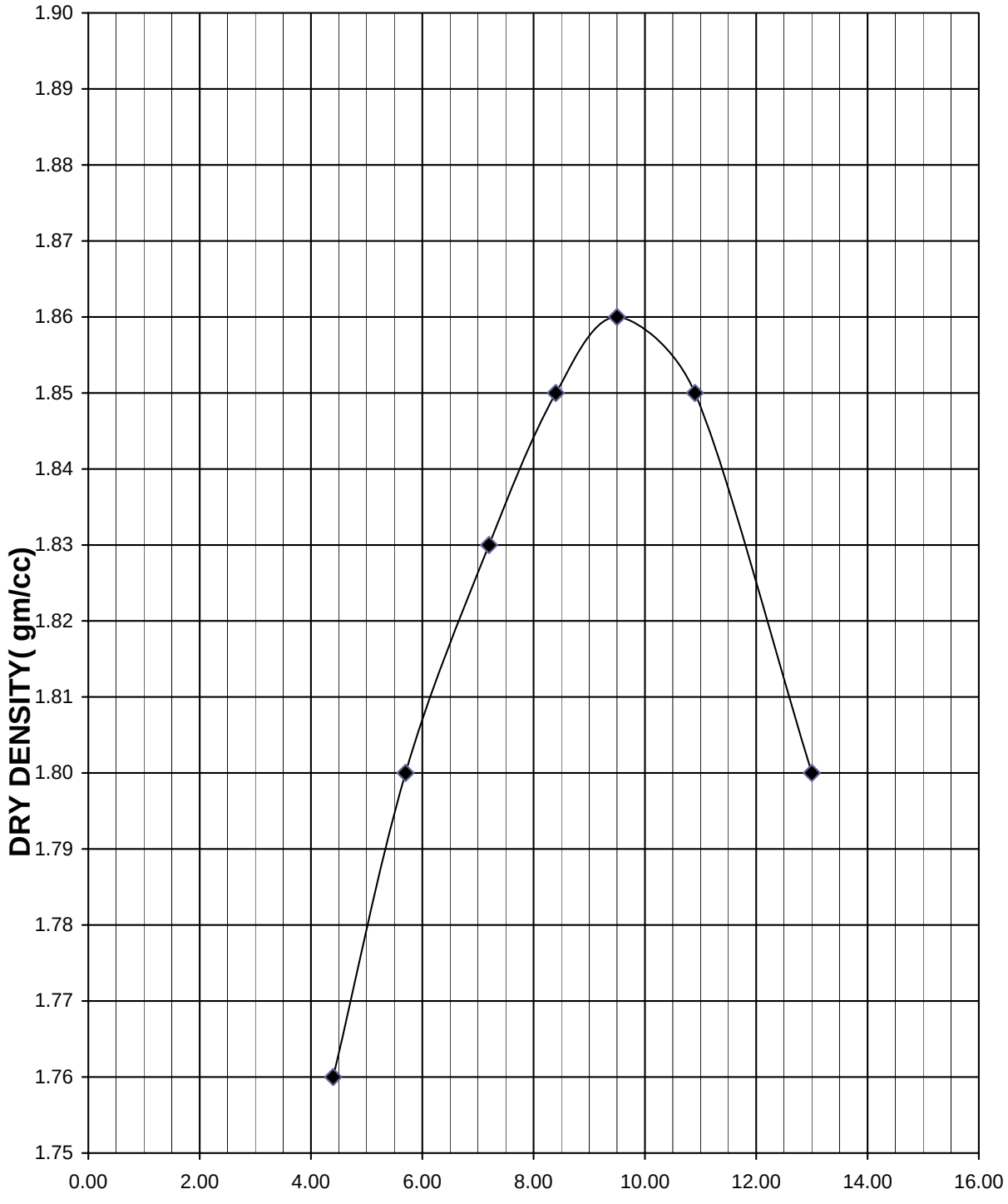


CBR CURVE

Penetration, mm	CBR,%
2.5	8.8
5.0	8.5

TRIAL PIT NO. 5 Depth (mm) 0.50-0.75

Sheet NO. 116

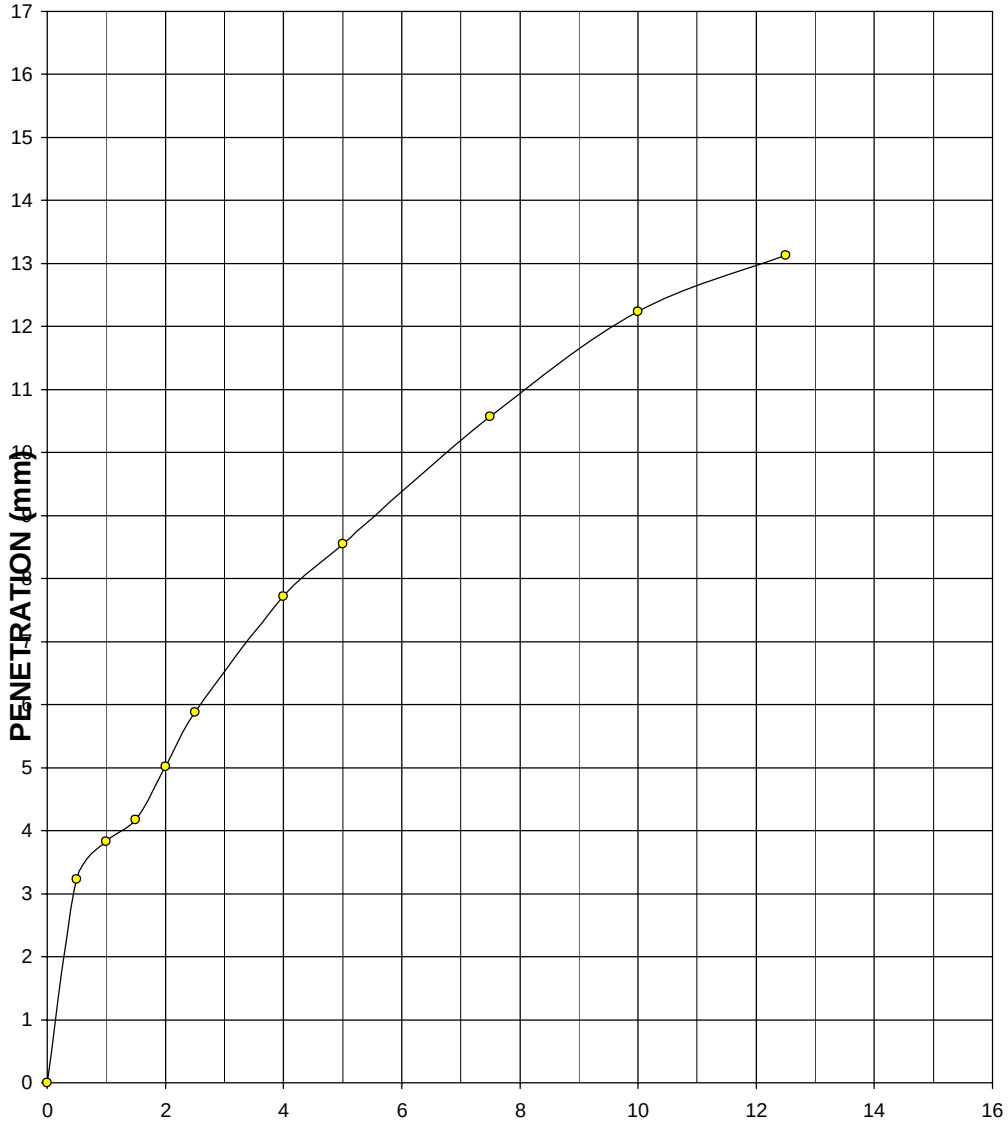


COMPACTION CURVE

Trial Pit No. - 5 Depth (m) 0.75 To 1.00

SHEET NO. 117

CORRECTEDLOAD ON PLUNGER IN Kg/cm2



CBR CURVE

Penetration, mm	CBR,%
2.5	8.4
5.0	8.1

TRIAL PIT NO. 5 Depth (mm) 0.75 to 1.00

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