

Ref. 984/94/NPD/jaf  
Client. Pratley Perlite

30 March 1995  
Project. "New product"

## LABORATORY REPORT : EVALUATION OF PERLITE "NEW PRODUCT"

### CLIENT

Pratley Perlite, PO Box 3055, Kenmare, 1745.

### SABS ACCREDITATION

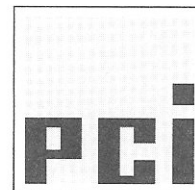
Except where indicated thus (\*) the results given in this laboratory report were obtained from tests conducted within the scope of **SABS Certificate of Listing - Accredited Test Facilities No. LTF 0003**. Comments are not covered by the certificate because of their interpretive nature.

### BRIEF

PCI was requested to carry out a series of tests to evaluate a new Perlite product. After commencement of the work additional tests were requested. The work was therefore basically carried out in two phases. For all mixes it was requested that water be added to bring the mixes to a consistence suitable for placing on site. In the lists of tests requested (which follow) the test procedure adopted is shown in parenthesis.

In phase one the following tests were requested on mixes having nominal proportions (by volume) of 3:1, 6:1 and 10:1. Later a 4,5:1 mix was included for consistence and strength testing only:

- ◆ 7-day and 28-day compressive strength on specimens cured
  - (a) in water
  - (b) in air
- (SABS Method 863).
- ◆ Permeability tests at 28 days (using the old procedure of DIN 1048).
- ◆ Wet density (determined on 100-mm cube specimens by weighing immediately after demoulding).



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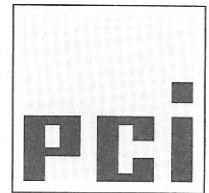
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- ◆ Dry density and rate of moisture loss (determined by weighing to constant mass 100-mm cube specimens dried on the laboratory bench and in a drying oven held at a temperature between 100 °C and 110 °C).
- ◆ Initial drying shrinkage (to SABS Method 836 except that no control specimens were used).
- ◆ Wetting expansion (to SABS Method 836).
- ◆ Slump (to PCI TM 6.2)
- ◆ Flow (to SABS Method 862-2)
- ◆ Air content (to SABS Method 1252)
- ◆ Water retentivity (to BS 4551)
- ◆ Consistence retentivity (to BS 4551)
- ◆ ISO flexural and compressive strength (using the procedure of EN 196)
- ◆ Modulus of elasticity (using PCI TM 7.6)
- ◆ To check and comment on the "plasterability" of each mix.

In phase two, PCI was requested to undertake strength tests and limited shrinkage tests on nominal 3:1, 4,5:1, 6:1 and 10:1 (volume) mixes covering a range of consistence between 40-mm slump and 120-mm slump. It was agreed that only two specimens would be cast from each mix for shrinkage tests.

## **MATERIALS**

Initially two x 10-kg (100 l) packets of Perlite "New product" were delivered for phase one testing. A further packet was delivered later for phase two testing. OPC ex Blue Circle Lichtenburg was used throughout.



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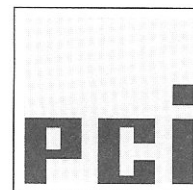
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## **TRIAL MIX CONSISTENCE**

Phase one was carried out with fairly wet mixes (slump of 100-mm or more and a flow of approximately 450 mm). Each nominal mix in phase two was made to a dry and a wet consistence, the difference in water content between mixes being approximately 5 l/10 kg packet or perlite (a range of approximately 200-mm slump or 200-mm flow).

## **RESULTS**

- ◆ The results for phase one are given in Table 1.
- ◆ The results for phase two are given in Table 2.
- ◆ The rate of moisture loss for air-dried and oven-dried 100-mm specimens is shown graphically in Appendices A to D.
- ◆ Standard cube compressive strengths for phases one and two are shown graphically in Appendix E.
- ◆ ISO compressive strengths for phases one and two are shown in Appendix F.
- ◆ Drying shrinkage results for phases one and two are shown in Appendix G.



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**Table 1:** Summary of phase one results

Nominal proportions (vol)	3:1	4,5:1	6:1	10:1
Cement content per 10 kg (100 ℓ) perlite (kg)	50	37,500	25	15,152
Water content per 10 kg (100ℓ) perlite (kg)	28,550	28,600	28,672	28,672
Slump (mm)	100 - 120	70 - 90	105	45+*
DIN flow (mm) (*)	450	450	450	400+
Air content (%) (*)	18,5	20	21	21
Resultant C/W ratio	1,75	1,31	0,87	0,39
Wet density on demoulding (kg/m <sup>3</sup> )	1 104	-	724	712
Oven-dry density (kg/m <sup>3</sup> )	808	-	425	337
DIN 1048 Permeability (Max Pen mm)	13	-	120	120
Static modulus of elasticity (GPa)	6,45	-	1,41	0,75
Drying shrinkage (%)	0,162	-	0,118	0,103
Wetting expansion (%)	0,146	-	0,111	0,098
7-day ISO flexural strength (MPa)	2,1	1,3	0,6	0,35
7-day ISO compressive strength (MPa)	6,5	2,4	0,9	0,45
7-day 100 mm cube compressive strength (MPa)	7,3	3,3	1,2	0,6
7-day 100 mm dry cured cube compressive strength (MPa)	7,0	-	1,5	0,6
28-day ISO flexural strength (MPa) (*)	2,5	1,7	0,8	0,5
28-day ISO compressive strength (MPa) (*)	6,6	3,3	1,4	0,8
28-day 100 mm cube compressive strength (MPa)	10,9	4,6	2,2	1,3
28-day 100 mm dry cured cube compressive strength (MPa)	7,7	-	1,8	0,9
Plasterability	Yes	Yes	Yes (just)	No
Water retentivity (%) (*)	89,4	85,6	82,1	81,5
Consistence Retentivity (%) (*)	33,9	32,1	37,4	52,8
ASTM C230 flow table reading (mm)	210	208	202	190

\* This value is low because of rapid water loss at the base of the slump cone.

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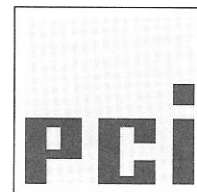
**Table 2:** Summary of phase two results

Nominal mix	3:1			4,5:1		6:1		10:1	
Test	Low	Med	High	Low	High	Low	High	Low	High
Water for 10 kg pack (ℓ)	23	26	29	19,2	24,2	19,2	24,2	19,2	24,2
Slump (mm)	55	80	250	45	240	50	230	30+	90+
Flow (mm) (*)	370	490	635	380	580	365	565	355	570
Measured air content (%) (*)	12	15	16	15	18	21	21	22	21
Drying shrinkage (%)	0,168	0,174	0,163	0,183	0,192	0,158	0,155	0,122	0,116
Wetting expansion (%)	0,144	0,145	0,143	0,165	0,165	0,151	0,138	0,102	0,095
7-day ISO flexural strength (MPa) (*)	3,7	2,6	1,9	3,4	2,0	1,5	1,1	-	-
7-day ISO compressive strength (MPa) (*)	14,2	7,3	5,0	12,6	5,2	3,9	2,3	-	-
28-day ISO flexural strength (MPa) (*)	4,9	3,6	2,7	4,2	2,5	1,8	1,3	-	-
28-day ISO compressive strength (MPa) (*)	19,8	12,3	7,5	16,9	6,3	4,4	2,9	-	-
7-day 100-mm cube strength (MPa)	16,9	10,8	7,3	15,6	6,9	4,7	3,0	1,2	0,8
28-day 100-mm cube strength (MPa)	23,0	15,0	10,0	19,0	8,7	6,0	4,3	1,7	1,4

## COMMENTS

### General

- ♦ It was difficult to obtain specific consistences. It was observed that the consistence achieved was very dependent on mixing time. All trial mixes were done using a pan mixer or a Hobart mixer. Mixing was therefore very thorough and the generation of entrained air very efficient (this might not be the case if drum mixers are used on site). Because of these difficulties it was considered better in phase two to measure properties over a range of water contents rather than a range of slumps.



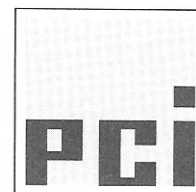
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- ◆ As the perlite product is marketed dry it may be useful to the client to print the required quantity of water on the packet. Fortunately the water requirement of the product is reasonably consistent over a wide range of aggregate:cement ratios. Alternatively the client must be advised to add the water slowly during mixing over a period of time to activate the admixture in case the required slump is exceeded.
- ◆ The mixes used in phase one were wetter than might be used on site. The physical properties, measured in this phase, are therefore probably more conservative and safer to adopt.
- ◆ The packet of Perlite submitted for phase two testing was insufficient and the quantity had to be augmented with Perlite from the first consignment. In hindsight these materials should have been preblended before embarking on phase two. As it happened, the 3:1 mixes in phase two were made up mostly with Perlite from remnants of the first consignment and the remaining mixes with Perlite from the second consignment. The results highlight differences between material from the first and second consignments. Perlite from the first consignment required more water to achieve a given consistence. Strengths could therefore be expected to be lower. As the 3:1 mixes in phase two were proportioned using mostly Perlite from the first consignment, it is understandable that the wetter mix gave similar results to the 3:1 mixes of phase one.

### **Compressive strength**

- ◆ For richer mixes the moulding water content had a large influence on the resultant consistence, compressive strength and flexural strength. Its influence diminished as the aggregate:cement ratio increased.
- ◆ The compressive strengths achieved were well above average for a lightweight mortar using OPC.
- ◆ The relationship between 7-day and 28-days strength are normal for standard-cured specimens but not for air-cured specimens.
- ◆ Specimens dry-cured for 28-day yielded strengths approximately 70% of standard-cured specimens. At 7-days there was virtually no difference.
- ◆ The results of the ISO tests follow a similar pattern to those for the 100-mm cube specimens.



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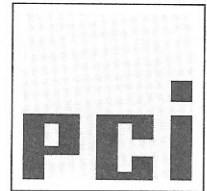
- ◆ The results of the ISO tests follow a similar pattern to those for the 100-mm cube specimens.

### Density

- ◆ Wet densities varied from approximately  $700 \text{ kg/m}^3$  to  $1\,100 \text{ kg/m}^3$ . Dry densities varied from approximately  $300 \text{ kg/m}^3$  to  $800 \text{ kg/m}^3$ .
- ◆ In the process of establishing density by measuring to constant mass, data was obtained for the production of graphs showing the rate of moisture loss in Appendices A to D.
- ◆ With oven drying at  $100^\circ\text{C}$  specimens were virtually dry within 24 hours. With air drying under favourable drying conditions ( $22 - 25^\circ\text{C}$  and RH below 50%) the specimens took longer than two weeks to dry (see Appendix D). When it is borne in mind that the cube specimens used present a high surface area to volume ratio, in situ placed Perlite is likely to take longer, but this would obviously depend on prevailing circumstances. No micro-cracking of the specimens was observed for both methods of drying.

### Permeability

- ◆ According to DIN 6.5.72 a concrete with a thickness of approximately 100 to 400 mm will be waterproof if the maximum penetration does not exceed 50 mm. It is further stated that the W/C ratio should not exceed 0,60 (C/W  $\leq$  1,70).
- ◆ The 3:1 mix (cast in 150-mm cube specimens) was deemed to be watertight. This may be partially due to the mix having a water/cement (cement/water) ratio of 0,57 (1,75) and partially due to the high air content (18,5% air).
- ◆ The 6:1 mix was not watertight. There was very little passage of water through the 150-mm specimens at 1 bar pressure but this increased significantly when pressure was increased to 3 bars - to the extent that the test had to be shut down overnight as the water reservoirs would have been depleted. The test had to be stopped soon after the pressure was raised to 7 bars.
- ◆ The 10:1 mix was not watertight. At 1 bar pressure the test had to be shut down overnight and was stopped early on the second day.



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### **Initial drying shrinkage and moisture movement**

- ◆ Differences in shrinkage properties were observed between the two consignments of Perlite. This can be clearly seen in Appendix G.
- ◆ The shrinkage values are relatively low for lightweight mortar.
- ◆ The shrinkage values are only slightly affected by change in consistence but significantly affected by changed in cement content.
- ◆ Wetting expansion values are above average for conventional aggregate but quite normal for lightweight aggregate. Generally, wetting expansion values are approximately 90% of drying shrinkage values. With conventional aggregates the relationship is generally between 65% and 70%.

### **Slump testing**

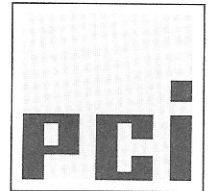
There appear to be certain anomalies in slump readings, in particular for the 10:1 mixes. The reason for this is that if slump tests are not done quickly, water bleeds from the mix at the base of the slump cone leaving a mortar which possesses poor flow properties. In these situations the flow test is considered to be a better test.

### **Air content**

- ◆ The measured air content increased with increasing consistence and with decreasing cement content.
- ◆ Mostly air contents were in the order of 20%. Notable exceptions were the rich 3:1 mixes, particularly at the drier consistence.

### **Water and consistence retentivity**

- ◆ BS 4551 recommends that when masonry cement is used, the water retentivity should be between 70% and 95%. The European standard for masonry cement (EN 413-1) specifies that the water retentivity should fall between 80% and 95%. PCI believes that for good workability the value should fall between 85% and 95%.



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- ◆ The water retentivity for 3:1 and 4,5:1 mixes by test and observation was considered to be satisfactory. For the 6:1 mix it was considered to be borderline. Water retentivity was observed to be poor for the 10:1 mix.
- ◆ Consistence retentivity results are very low compared with conventional aggregate mortars which generally have values in the order of 50% to 60%. The consistence retentivity value for the 10:1 mix was rather surprising but was confirmed after re-testing. It is believed that the high result is due to the standard weight ball more easily displacing lean and relatively dry lightweight aggregate after removal of most of the water by suction. The test should therefore not be applicable in these circumstances.

#### **Plasterability**

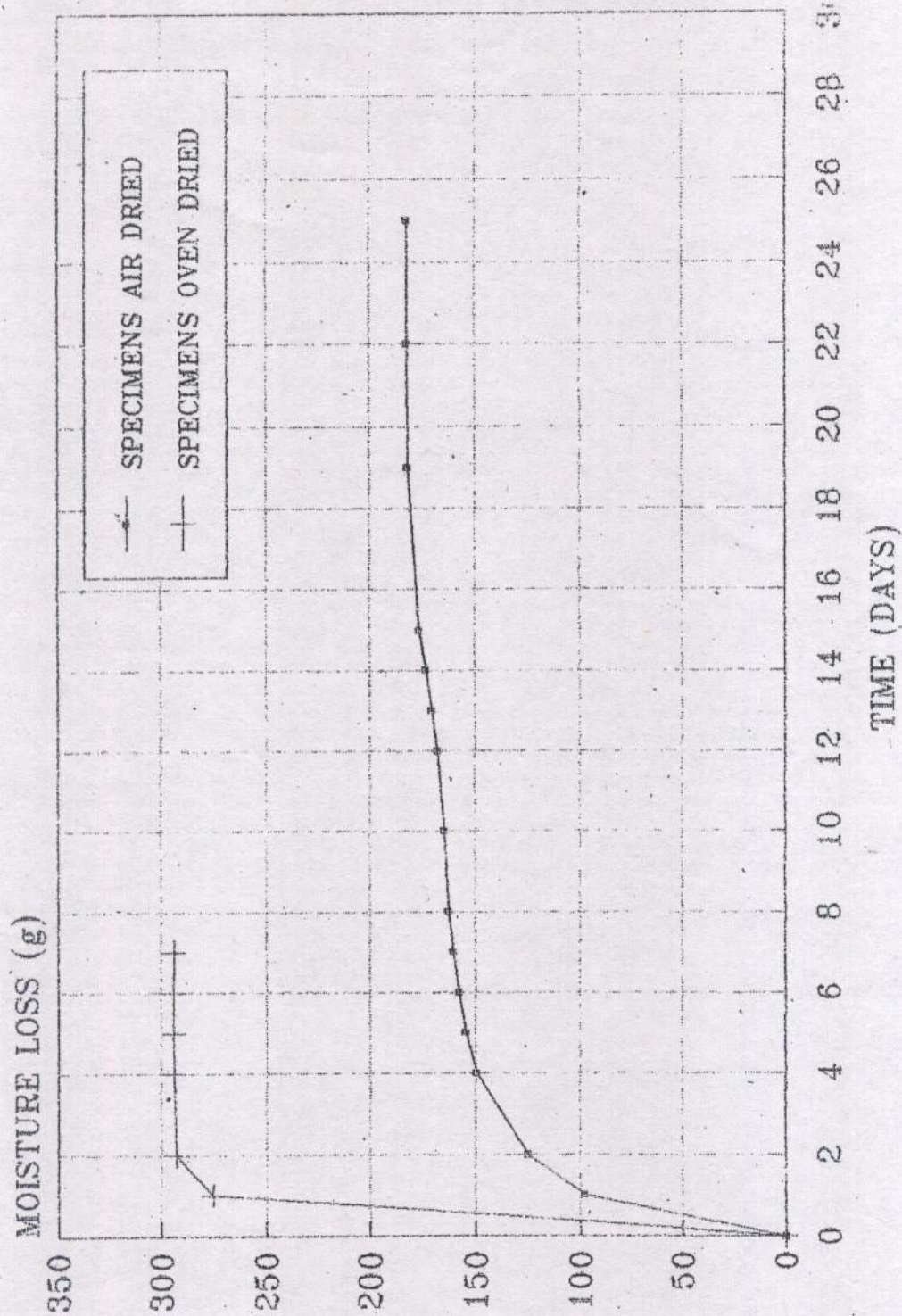
- ◆ The ability to successfully plaster with the various nominal mixes is in line with the measured and observed water retentivities.
- ◆ The 3:1 and 4,5:1 mixes could be used for plaster without difficulty. The 6:1 mix could be used for plaster but the mix was lacking adequate cohesion. The 10:1 mix was unsuitable for plastering.

A handwritten signature in black ink, appearing to read "N P Doulgeris", is written over a horizontal line.

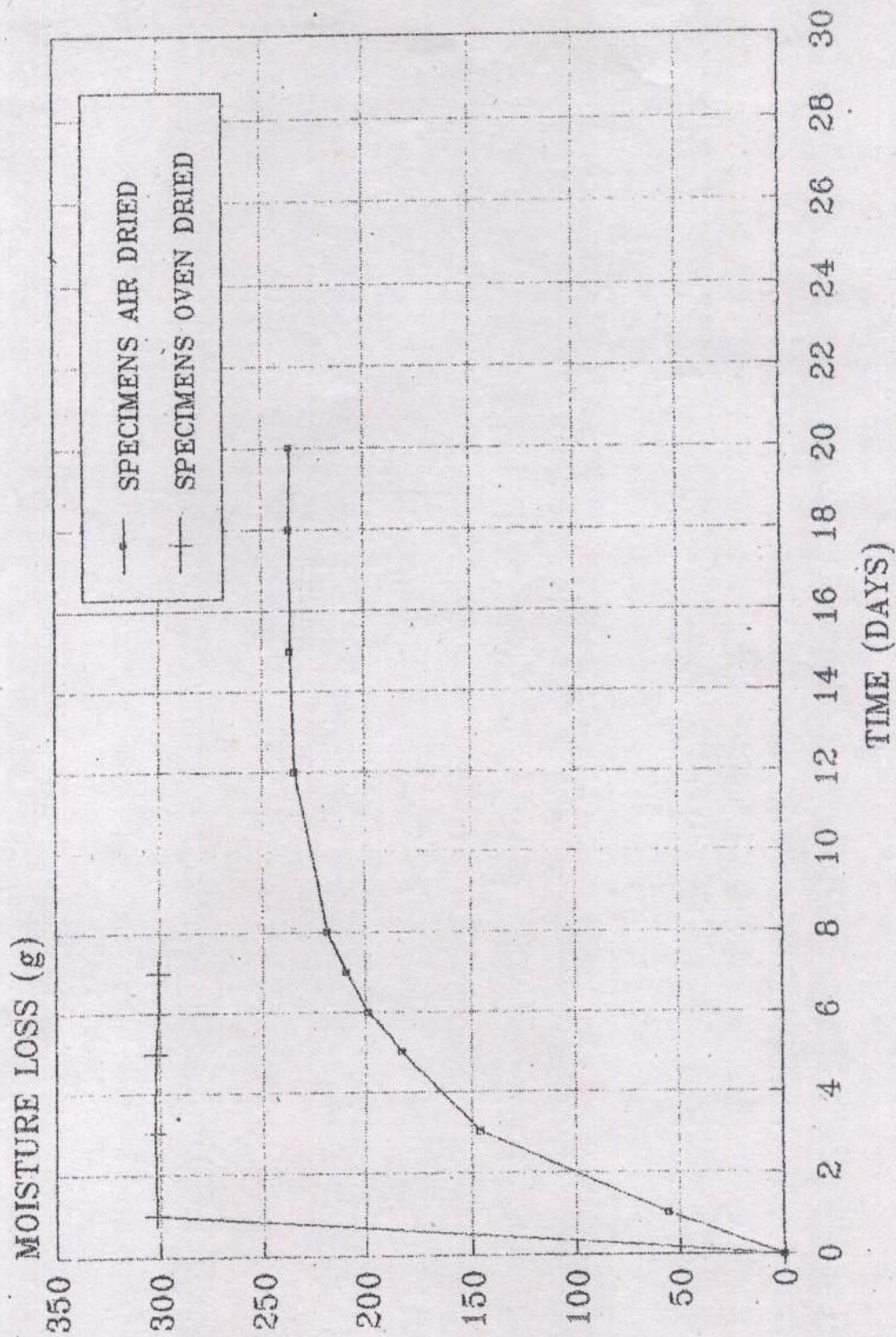
N P DOULGERIS

This report was reviewed by P C Taylor Pr Eng

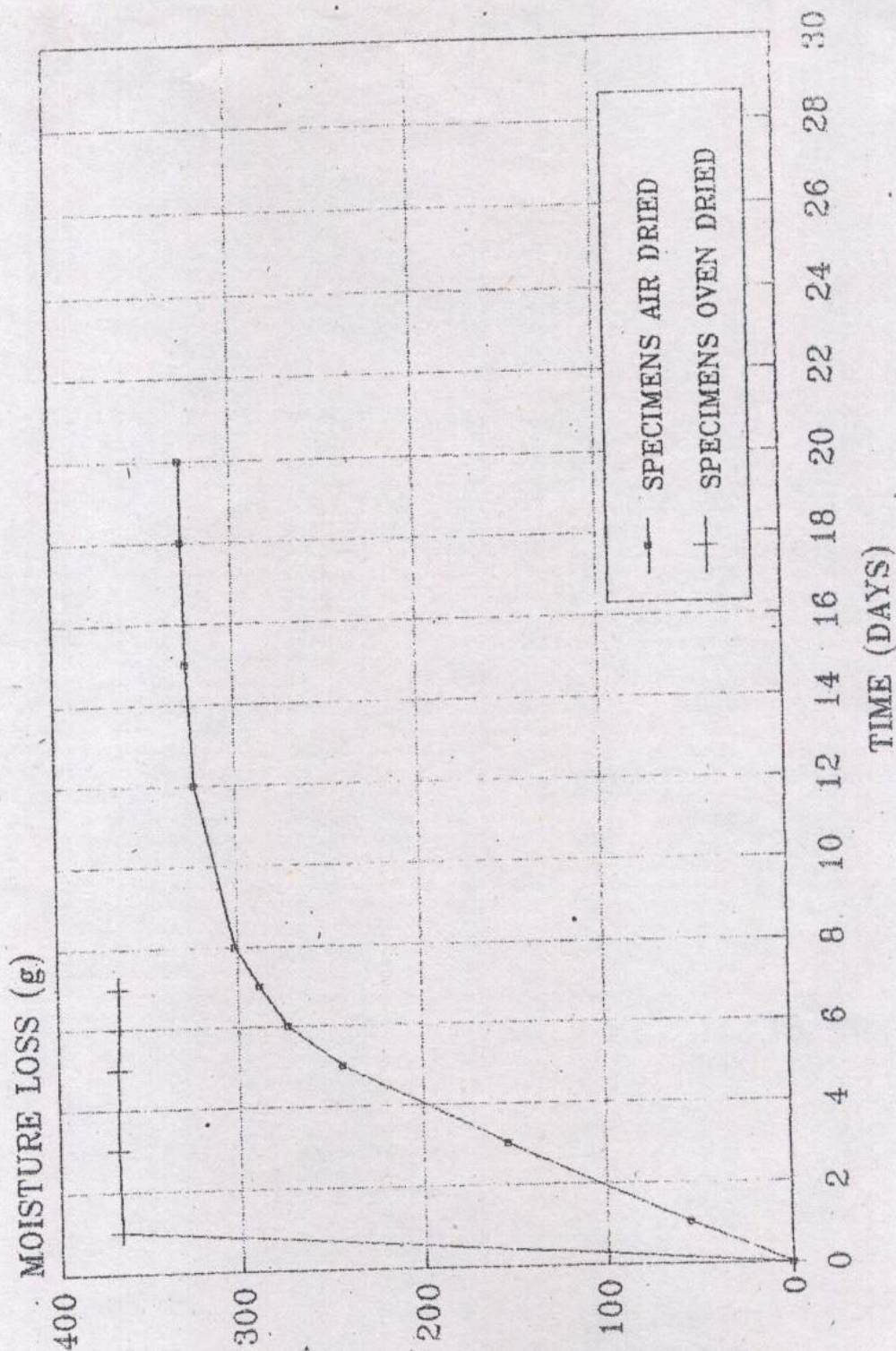
APPENDIX A-PRATLEY PERLITE -3:1 MIX  
RATE OF LOSS OF MOULDING MOISTURE-perl-a



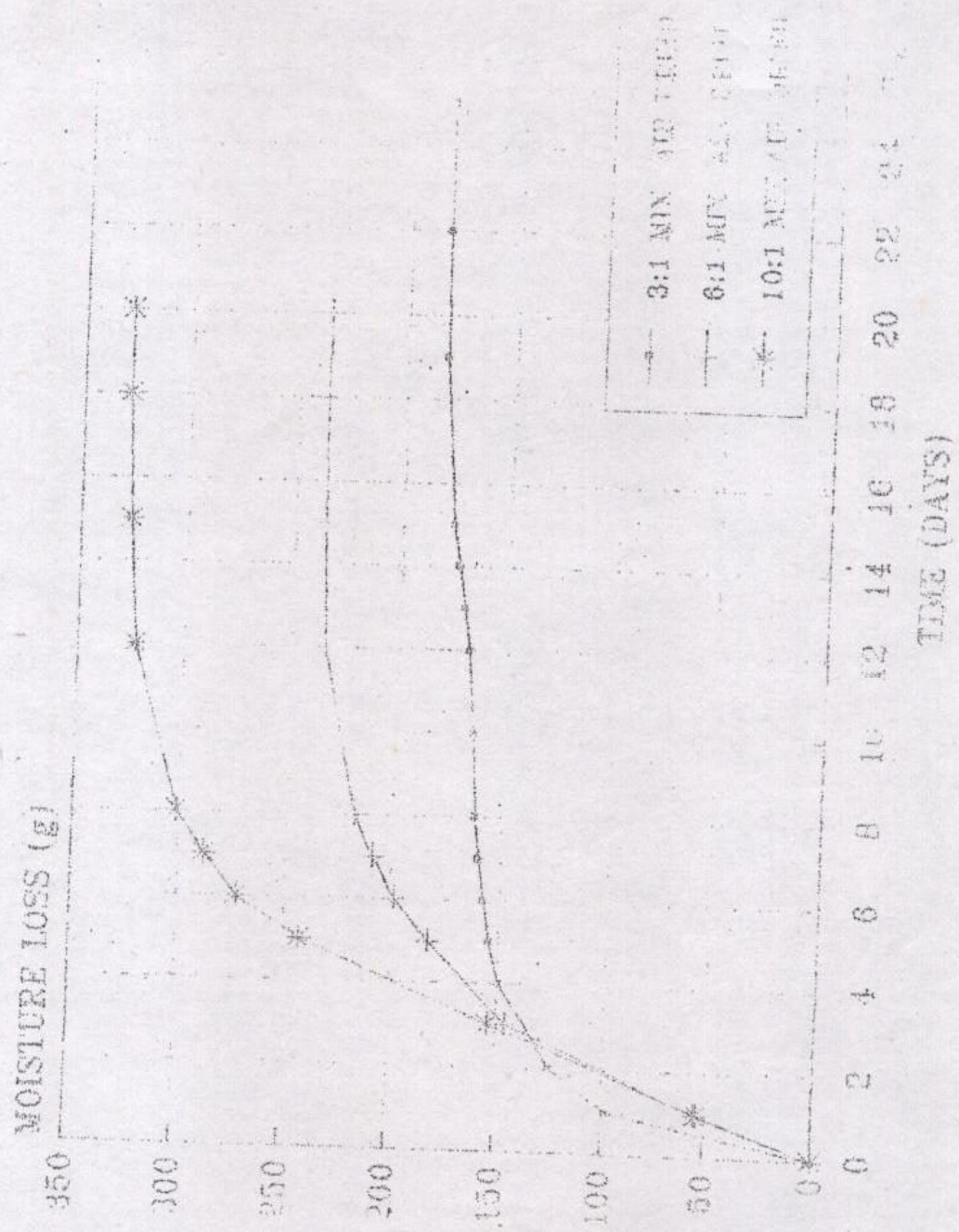
# APPENDIX B-PRATLEY PERLITE -6:1 MIX RATE OF LOSS OF MOULDING MOISTURE-perl-b



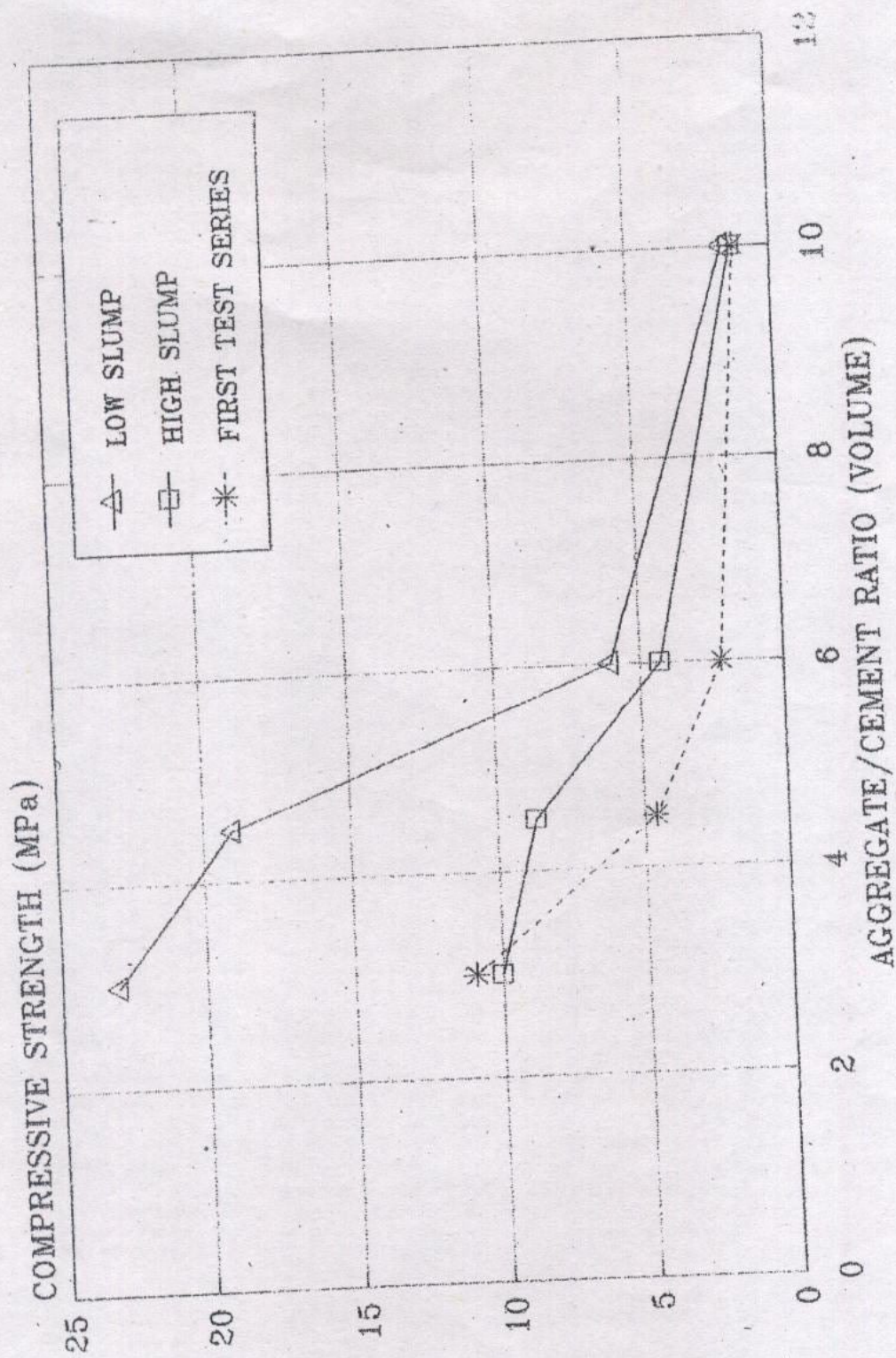
APPENDIX C-PRATLEY PERLITE -10:1 MIX  
RATE OF LOSS OF MOULDING MOISTURE-perl-c



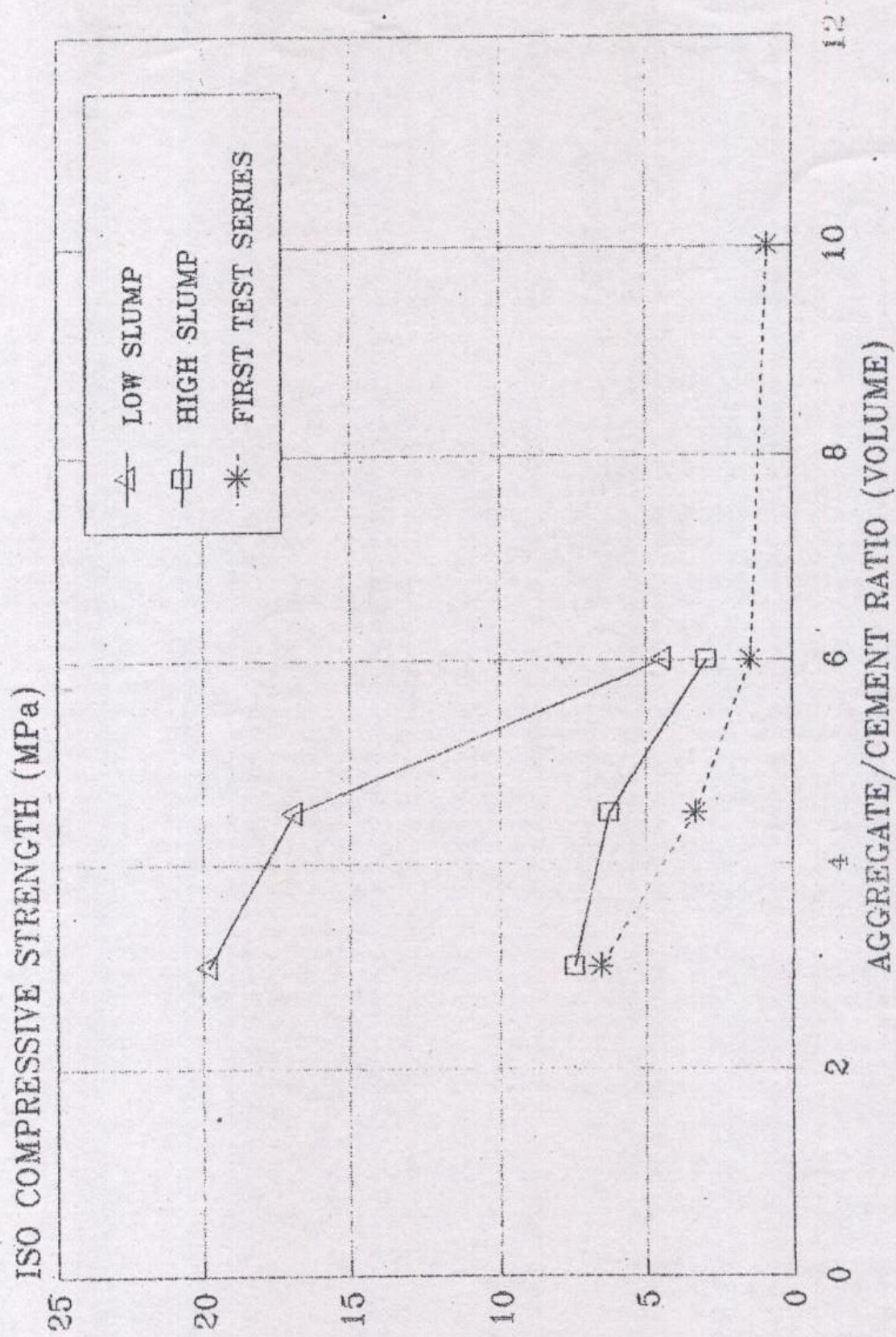
# APPENDIX D-THIRTY PERLITE (PERLITE) RATE OF LOSS OF MOULDING MOISTURE



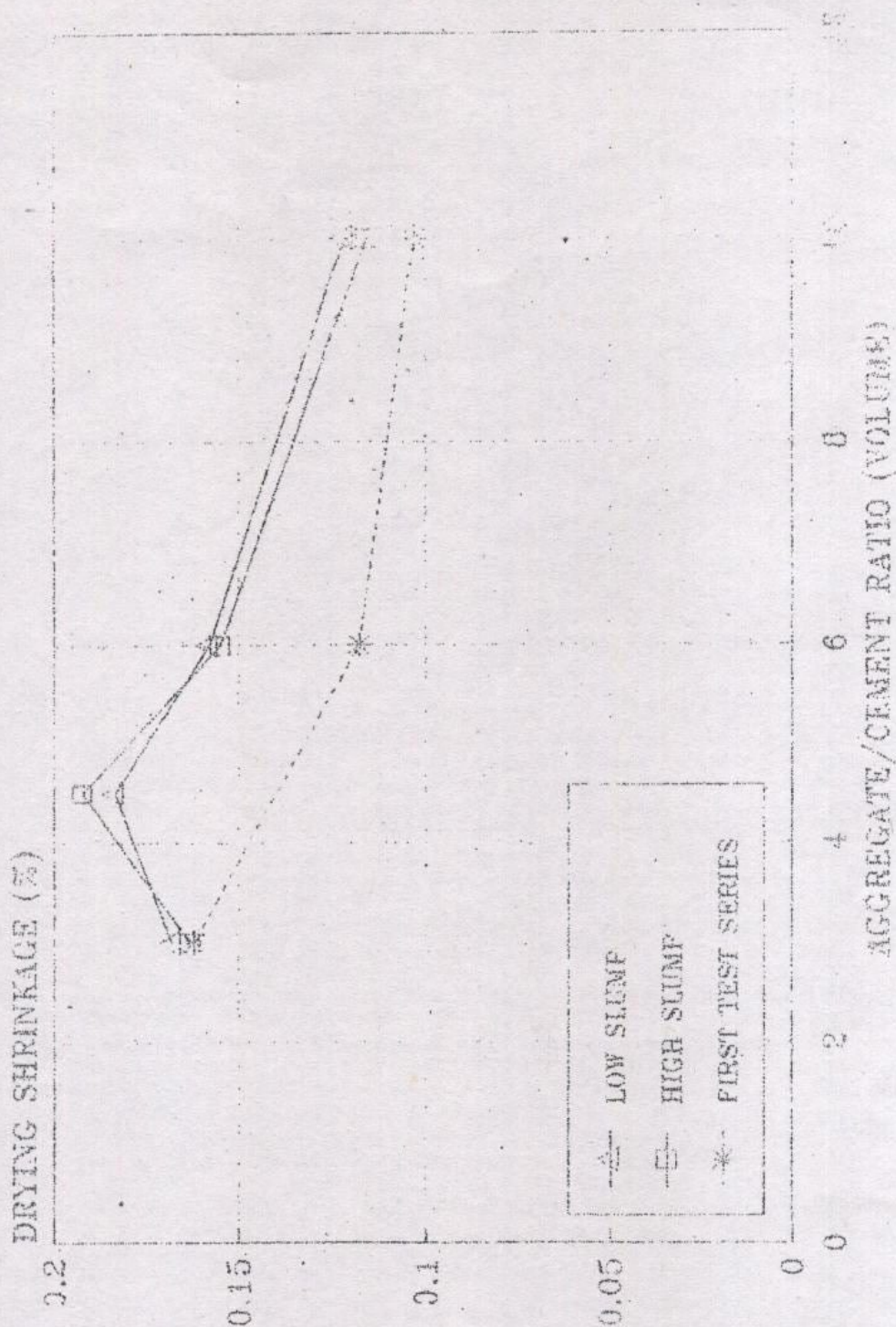
APPENDIX E-PRATLEY PERLITE-984/95  
STRENGTHS - RANGE OF CONSISTENCE-perl-e



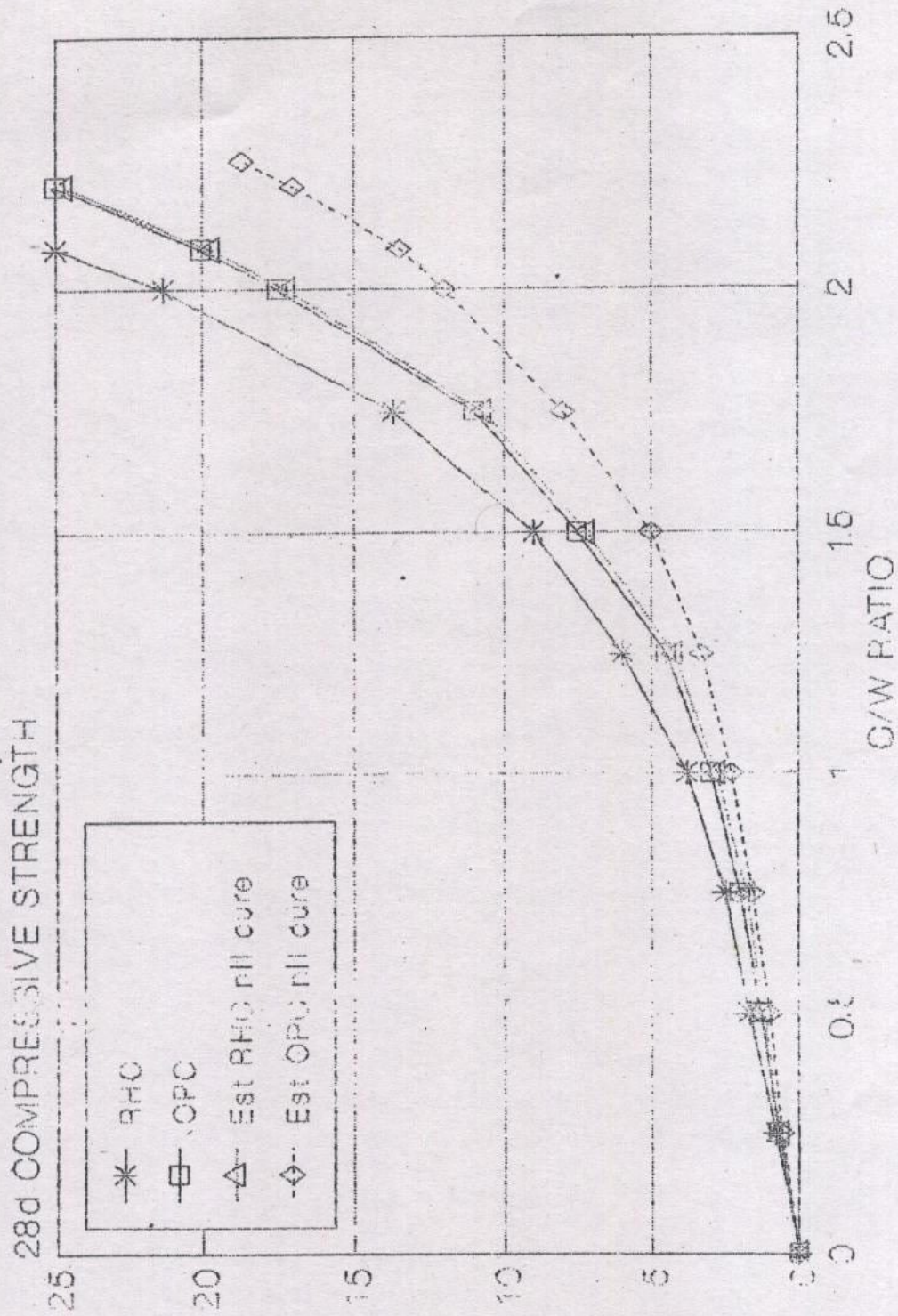
# APPENDIX F-PRATLEY PERLITE - perl-f ISO STRENGTHS FOR A RANGE OF CONSISTENCE



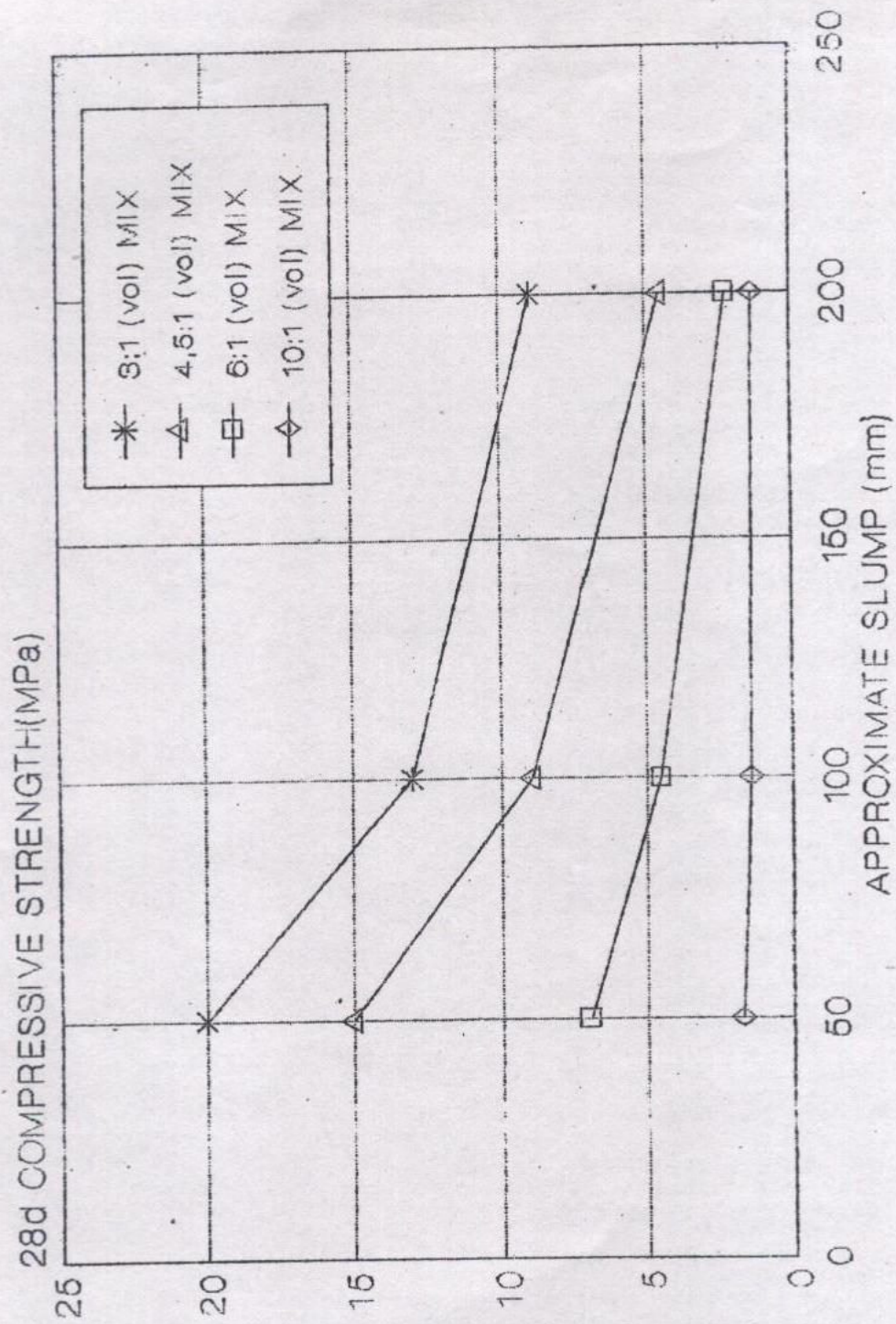
# APPENDIX G--PRATLEY PERLITE -- perlite DRYING SHRINKAGE (RANGE OF CONSISTENCY)



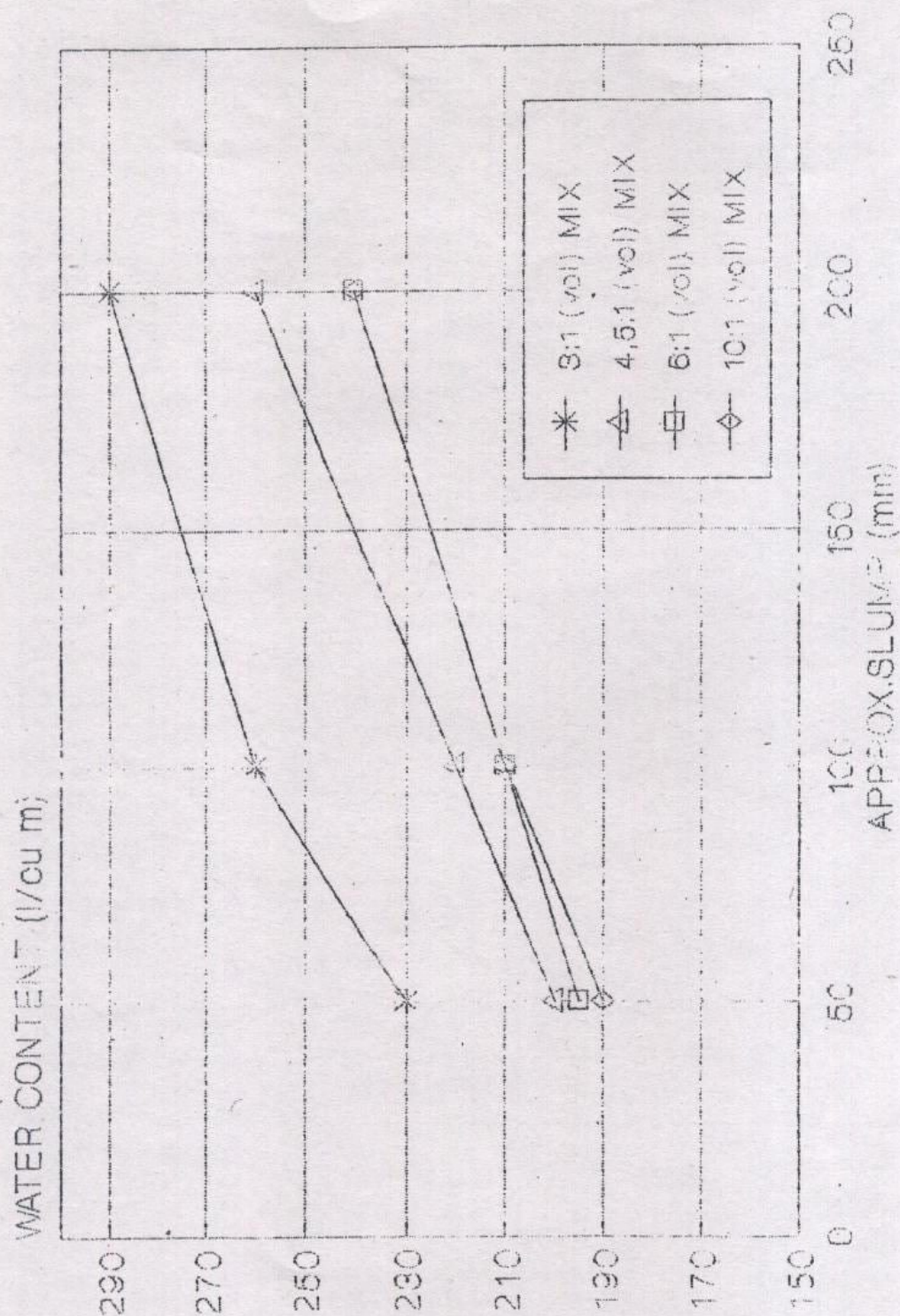
# PERLITE (perl-a) C/W RATIO vs COMPRESSIVE STRENGTH



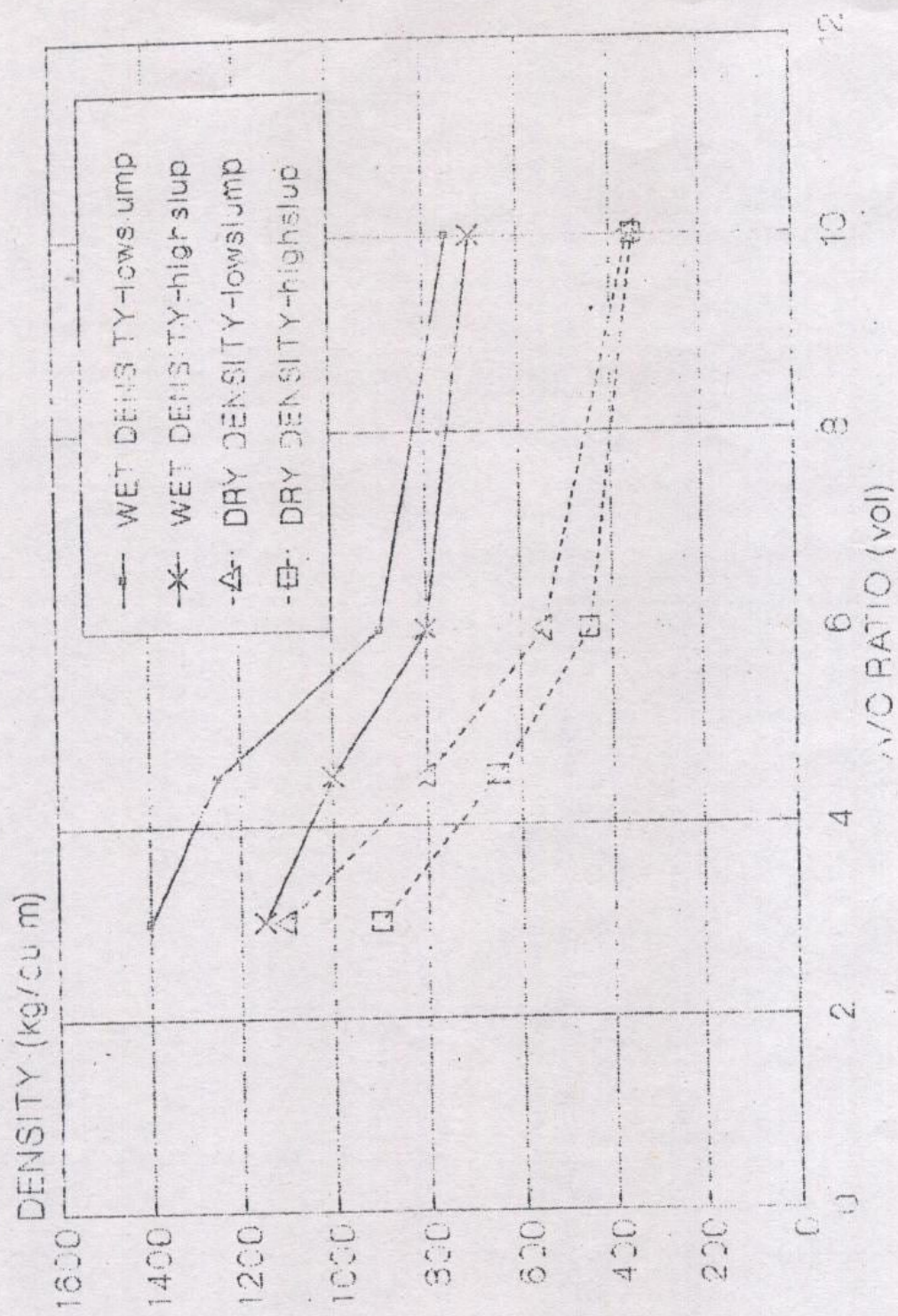
# PERLITE (perl-b) APPROX SLUMP vs COMPRESSIVE STRENGTH



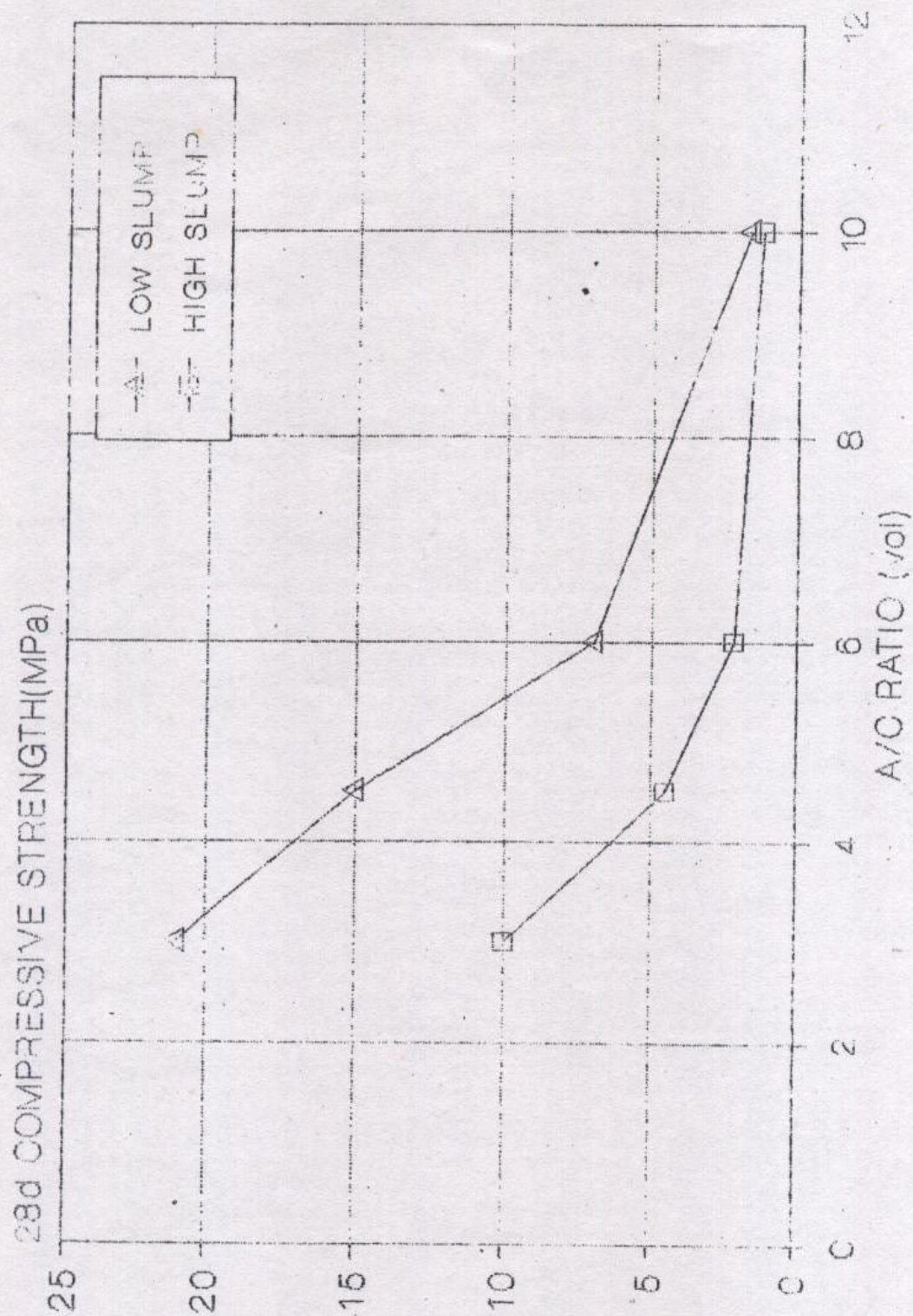
# PERLITE (perl-c) WATER CONTENT vs SLUMP



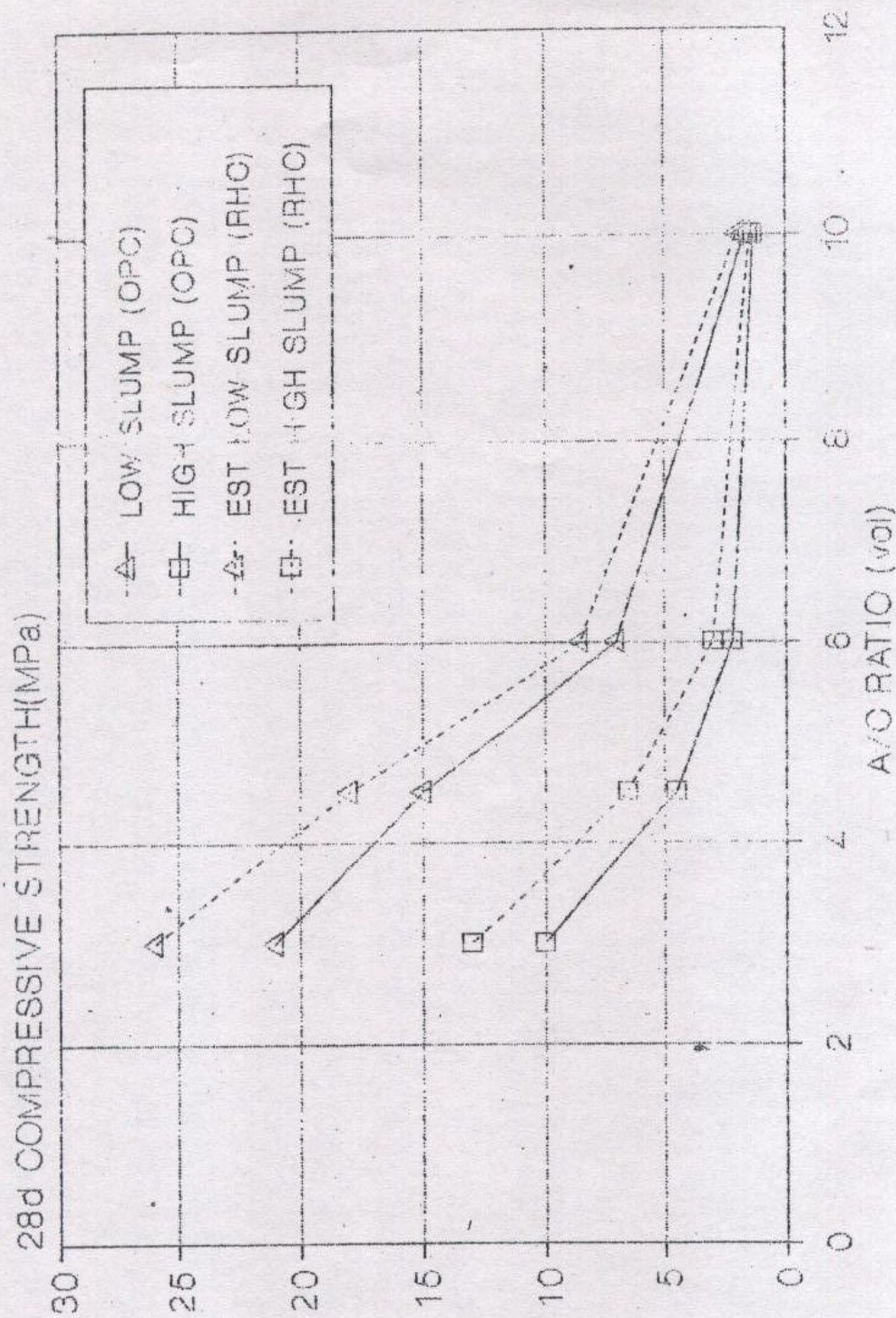
# PERLITE (perl-d) DENSITY vs A/C RATIO



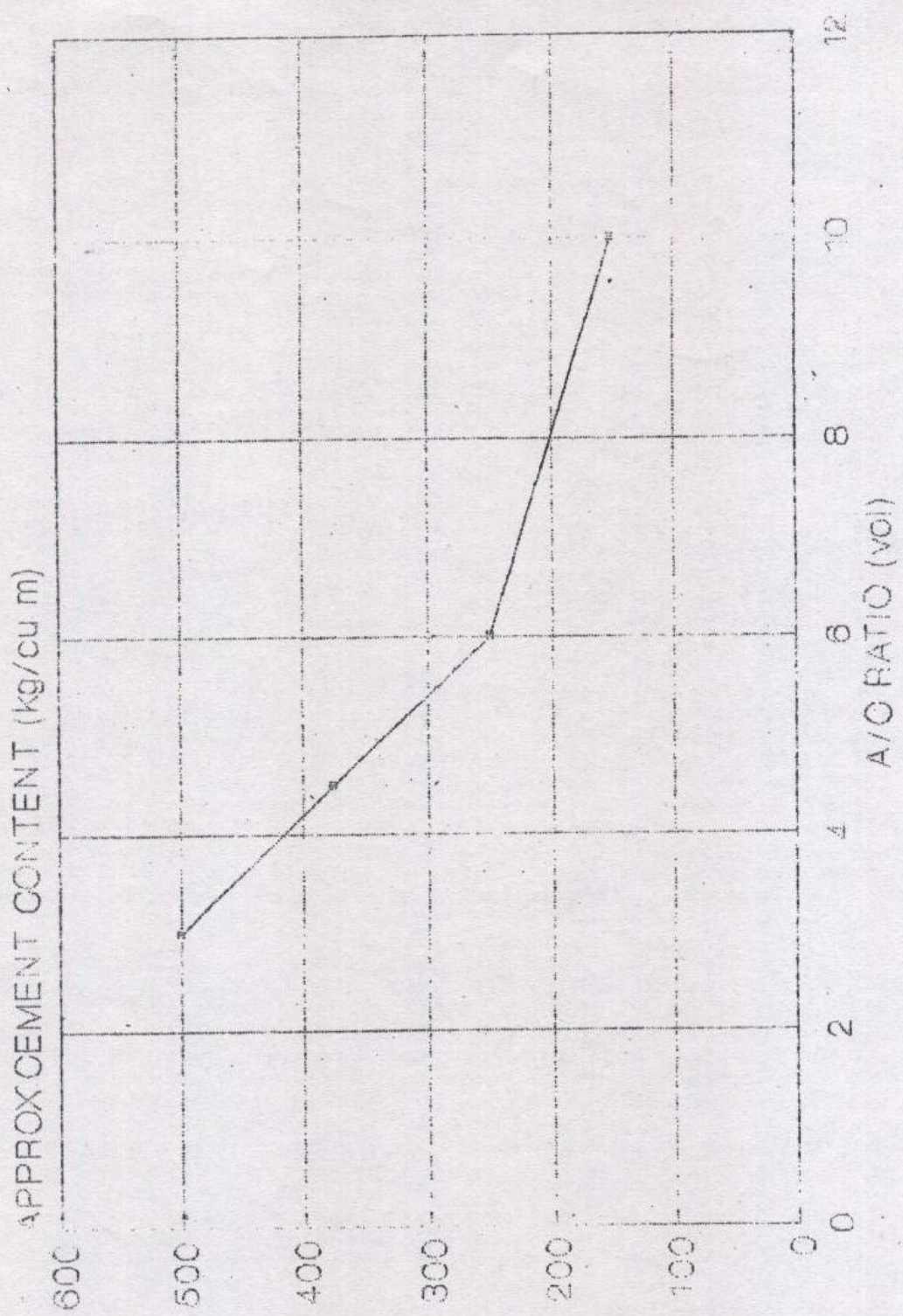
# PERLITE (perl-e) A/C RATIO (vol) vs COMPR.STRENGTH



# PERLITE (perl-f) A/C RATIO (vol) vs COMPR.STRENGTH



# PERLITE (perl-g) CEMENT CONTENT vs A/C RATIO (vol)



# PERLITE+OPC (perlite) C/W RATIO vs COMPRESSIVE STRENGTH

