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Effect of Capping Material on Strength of Concrete Cylinders/Cores

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Abstract: *Compression testing is most commonly used as quality control measure in concrete masonry production and construction. For checking strength we required smooth surface for uniform load distribution. We use capping material to eliminate surface imperfection and provide uniform load distribution. This project aims to study the strength variation between the capped and uncapped concrete cylinders. The capping material is selected based on the multiple criteria including compressive strength, surface bonding, thickness, Poisson's ratio and hardness. Uncapped cylinders are chosen as control method and are compared against gypsum; cement paste, neoprene pad and steel caps. Cylinders are casted in 63mm, 75mm, 110mm, and 150mm. in diameter having height of 300mm. The main purpose behind to take various diameter is that to check the strength variation according to the surface area. We casted the cylinders in three grades such as M15, M30, and M45. The observed things while testing are cracking pattern, strength variation due to change in surface area, concrete grades, and capping material (bonded and unbonded capping). Bonded caps are gypsum and cement paste where as unbonded caps are neoprene pad and steel caps. For bonded caps we require some time for setting but for unbonded caps we don't require any setting time, from here we can say that unbonded caps are time efficient as compared to bonded caps.*

Keywords: *concrete, compression test, capping material, bonded, unbonded.*

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I. Introduction

The most common test is used for quality control of concrete units is the compressive strength test. The main purpose of compressive strength test is to simulate the actual strength that concrete units will withstand in the field. When we extract core or cast cylinder we do not get smooth even surface on one side and for testing of that cylinder or core we required smooth surface. For making smooth surface we use different types of capping materials these may be bonded and unbounded. The use of different types of capping material gives variation in strength and without capping the specimen also there is difference in result of tesr on cylinder or cores. Capping is the preparation of the ends of cylinders/cores specimen in order to ensure that specimens have smooth, parallel, uniform bearing surface that is perpendicular to apply axial load during compressive strength testing.

II. Literature Survey

2.1 Vichit- Vadakan, W., Carino, N. J., and Mullings, G. M. "Effect of elastic Modulus of Capping Material on Measured Strength Concrete Cylinders," Cement, Concrete, and Aggregate , CCAGDP, Vol.20, No, Dec. 1998, pp. 227-234.[1], Studied that end conditions of concrete cylinders tested in compression can have a significant effect on the measured strength of the cylinders, especially when high-strength concrete is used. The ASTM standard for bonded caps has requirements for minimum cube strength of the capping material and maximum cap thickness. The dynamic modulus of elasticity and modified cube strength (ASTM C 116) of various capping materials were evaluated as a function of age.

2.2 Lobo. C. L. Mullings . G. M. and Gaynor. R. D., "Effect of Capping Materials and Procedures on the measured Compressive Strength of High-strength Concrete," Cement, Concrete and Aggregates, CCAGPD. Vol.16, No.2 Dec.1994, pp.173-180.[2] They concluded that capping the ends of tests cylinders with neat cement paste caps, with a 50mm cube strength 85Mpa resulted in measured strengths equal to cylinders with ground ends for concrete with strengths upto 120Mpa.This was true for cap thickness of 1.6mm and 6.4mm. In this paper the effect of end conditions and testing procedures on the measured strength of 100mm x200mm concrete cylinders were evaluated. Two types of sulphur mortar caps applied 2 to 4 h before testing resulted in lower measured strength for 50Mpa concrete. Cube strength of sulphur mortars at

2 h were not significantly lower than the strength of concrete tested. When these two sulphur mortars were applied six or seven days before testing on 75Mpa concrete, both performed satisfactorily at both cap thicknesses. On 120 Mpa concrete, sulphur cap thickness at 4.8mm.which exceeds ASTM C 39 requirements of 3.2mm resulted in lower measured strengths. There was no significant difference between the two sulphur capping materials when applied six to seven days prior to testing.

2.3 Khamput P. and Kmnuantip C."Properties of Para-Rubber Plates Using as the Capping on Concrete Specimens for Compression Test instead of Molten Sulphur",[3] This paper aims to study the using Para-rubber plate for transferring the force on concrete specimen instead of capping with sulphur. Four formulas for mix design of Para-rubber plate are setup. Each formula is mixed in two rolls mill machine and formed the Para-rubber plate by compression moulding. The Para-rubber plates are taken into capping the concrete and tested the compressive strength. These results are compared with sulphur capping. From the result it is found that adding carbon back over 60 to develop hardness but the other properties are declined.

2.4 Dennis Vandergrift, Jr. Anton K. Schindler "The Effect of Test Cylinder Size on the Compressive Strength of Sulphur Capped Concrete Specimens" Highway Department of Civil Engineering at Auburn University Research Center and Department of civil engineering at auburn university[4]. In this research project was born from the need to determine a correlation between the strength of the standard size 6 x 12 inch. The new trend of using high-strength concrete in construction has caused a need for the use of 4 x 8 inch. Cylinders for assurance testing. A controlling factor that affects the size of specimen that can be tested in a compression machine is the strength of the concrete on evaluation. The objectives of this study are to review the factors that may affect the compressive strength, those that may affect the strength obtained by 4 x 8 in. and 6 x12 in. cylinders, and the variability associated with these tests. An extensive laboratory testing program was developed to evaluate the desired goals of the project. A total of 359 4 x 8 in. and 357 6 x 12 in. cylinders were tested. Cylinders and the variability associated with those results. The conclusions drawn from the literature review will help determine what factors to study during the laboratory component this research project.

2.5 Analysis of Bonded and Unbonded Capping Materials used in Determining the Compressive Strength of Concrete Masonry units and prisms, Hector Mexica Grivel "Department of Civil and Environment Engineering, BYU" Master of science[5]. This research project was divided in to two parts. The first part is a continuation of the project "Analysis of unbonded capping material used in determining the compressive strength of concrete masonry prisms" and second part of this research is to investigate alternative capping methods to determine the compressive strength of concrete masonry units. In this project or research testing are done on both concrete masonry unit(CMU) and prisma. Even though capping with gypsum is the time consuming and labour intensive, gypsum is the capping material that represents best. Two important features make gypsum the best capping material: first its high fluidity nature and second sets very fast and gains strength quickly. Cement paste could be considered an alternative capping material to gypsum, exclusively for hollow CMUs. However, cement paste takes more time for the cement paste to set and gain strength in comparison to gypsum.

2.6 W.J.Head, Professor of Civil Engineering And J.D.Folden,Jr.Graduate Research Assistant "Assessment of Steel Ends with Rubber Inserts as Capping Media for Concrete Cylinders"[6] The current states of practice in determine the compressive strength of concrete is to use cylindrical that are six inches on diameter and twelve inches long. Specimens must be capped so that the contact surface between the testing machine and the specimen is even planner. Capping is the time consuming process, not only in actual procedure but also in the time required for the caps to cure. Caps must cure for approximately two hours to attain sufficient strength so that they do not fail before the concrete. Steel ends caps with removable neoprene inserts can serve as an acceptable capping media for four inch diameter concrete cylinders that are either one or twenty eight days old when tested in unconfined compression. One day old six inch diameter concrete cylinders tested in confined compression are stronger than comparable four inch diameter specimens. Twenty eight day old, four inch diameter concrete cylinders tested in unconfined compression are stronger than comparable six inch diameter specimens.

III. Methodology

3.1 MATERIALS

Materials which used for the making of concrete cylinders are:

3.1.1 CEMENT (AS PER IS12269:53)

Cement is described as a material with adhesive and cohesive properties which make it capable of bonding Mineral fragments into a compact whole. It embraces large variety of cementing materials. For construction purposes the Meaning of the term cement is restricted to the bonding material used with stones, sand, bricks, building blocks, etc. The principal constituents of this type of cement compounds of lime, so that in

building and civil engineering we are connected with calcareous cement. The cements have property of setting in under water by chemical reaction releasing heat of hydration. So called as hydraulic cement.

3.1.2 SAND [IS 2386(part-2)]

Sand is naturally or artificially available material which is composed rock and mineral particles. It is found in different sizes but the size of sand should pass through 1.18mm sieve. It should be free from impurities such as vegetation and gravels. Some inert material such as sand, surkhi or cinder and lubricating material water, a paste is formed which is plastic in nature; this paste is known as mortar.

3.1.3 AGGREGATE [IS 383- 1970]

Aggregates are the important constituents of the concrete which give body to the concrete and also reduce shrinkage. Aggregates occupy 70 to 80 % of total volume of concrete. So, we can say that one should know definitely about the aggregates in depth to study more about concrete.

3.1.3 WATER [IS 456-2000]

Is the key ingredient, which when mixed with cement, forms a paste that binds the aggregate together. The water needs to be pure in order to prevent side reactions from occurring which may weaken the concrete, the role of water is important because the water to cement ratio is the most critical factor in the production of "perfect" concrete.

3.1.4 CAPPING

Capping is the preparation of the ends of cylinders/cores specimen in order to ensure that specimens have smooth, parallel, uniform bearing surface that is perpendicular to apply axial load during compressive strength testing.

Types of capping material:

1. Bonded capping material
2. Unbounded capping material

3.1.4.1 BONDED CAPPING MATERIAL

The capping material which required some time for settling and getting its strength is called as bonded capping material. Which is gypsum, cement paste.

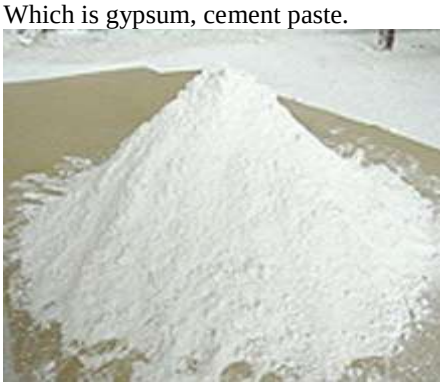


Fig.1 Gypsum

Fig.2 cement paste

3.1.4.2 UNBONDED CAPPING MATERIAL

The capping material which don't required any time for setting purpose or gaining strength purpose is called as unbonded capping material, which are neoprene pad, steel cap.

Fig.3 neoprene pad

Fig.4 steel cap

3.2 TESTS ON CEMENT

3.2.1. STANDARD CONSISTENCY TEST [IS 4031-part-5(1988)]

Standard consistency of cement test is defined as the standard consistency of a cement paste is defined as that consistency which will permit the vicat plunger to penetrate to a point 5 to 7mm from the bottom of the vicat mould.

A) Initial and final setting time:

Initial setting time duration is required to delay the process of hydration or hardening. Final setting time is the time when the paste completely loses its plasticity. It is the time taken for the cement paste or cement concrete to harden sufficiently and attain the shape of the mould in which it is cast.

Result:-

Standard consistency of cement we get = 30%

Initial setting time of cement = 40 minutes

final setting time of cement = 10 hrs

Fig.5 initial setting time

Fig.6 Final setting time

3.2.2 SPECIFIC GRAVITY OF ARTIFICIAL SAND

Specific gravity is the ratio of the density of a substance to the density of a reference substance; equivalently, it is the ratio of the mass of a substance to the mass of a reference substance for the same given volume. Specific gravity of sand is calculated by using pycnometer.

The water content result

$$w = [W_2-W_3] / [W_3 -W_1]*100\% \quad \text{.....Equation (1)}$$

an average of three determinations should be taken.

Hence after all this we get water absorption of sand is equal to 2%.

3.3 TESTS ON AGGREGATE

3.3.1 SPECIFIC GRAVITY [IS 2386 (part-3)]:1963

Specific gravity is the ratio of the density of a substance to the density of a reference substance; equivalently, it is the ratio of the mass of a substance to the mass of a reference substance for the same given volume. Specific gravity of aggregate after test we get as 3.09.

3.3.2 WATER ABSORPTION OF AGGREGATE [IS 2386 (part-3)]:1963

this test helps to determine the water absorption of coarse aggregates. After testing Water absorption of aggregate is 2%.

3.4 WORKABILITY TEST ON CONCRETE: [IS 1199(1959)]

casting for every grade we go for the slump cone test for testing of workability of concrete. For casting of cylinder slump height must be in range of 50mm-100mm. After the testing we have found that slump height for different grade is different.

For M15 is 95mm
for M30 is 80mm
for M45 is 70mm

3.5 CONCRETE MIX DESIGN [IS 10262(2000)]

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design.

For M15:- 1 : 2.10 : 3.56
For M30:- 1 : 1.82 : 3.14
For M45:- 1 : 1.61 : 2.28

3.6 CASTING,CURRING,CAPPING AND TESTING:

casting cylinder of various diameters are 63mm,75mm,110mm,150mm,As casting was completed we put the concrete cylinders in water for curing for 28 days, After 28 days we take out the cylinders from water and then we apply different capping materials on each concrete cylinder. We use different capping material i.e. Gypsum, steel cap, neoprene pad, and cement paste and one is unbounded and then we have done testing on CTM machine.

Fig.7 casting of cylinders

Fig.8 casting of cylinders

Fig.9 testing of cylinder

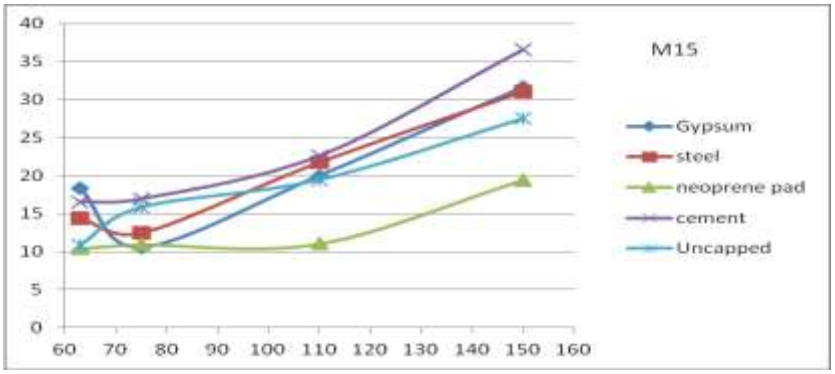
Testing Result

Table no.1 variation of strength after changing the grades and capping material

Grade of Concrete	Diameter of Cylinder (mm)	Capping Materials (Strength in N/mm^2)				
		Gypsum	Steel	Neoprene pad	cement	Uncapped Culinder
M15	63	18.38	14.43	10.42	16.57	10.84
	75	10.56	12.44	10.93	16.97	15.83
	110	19.98	21.73	11.05	22.645	19.46
	150	31.67	31.02	19.41	36.65	27.53
M30	63	12.55	14.96	14.43	17.36	13.36
	75	12.44	17.35	12.44	17.37	16.97
	110	35.6	28.56	21.04	29.46	25.60
	150	36.50	32.25	25.18	40.64	34.42
M45	63	21.38	25.12	16.03	18.71	25.12
	75	39.23	31.68	13.95	23.38	27.15
	110	47.52	45.59	31.03	36.65	42.73
	150	44.13	49.51	36.01	56.0	46.51

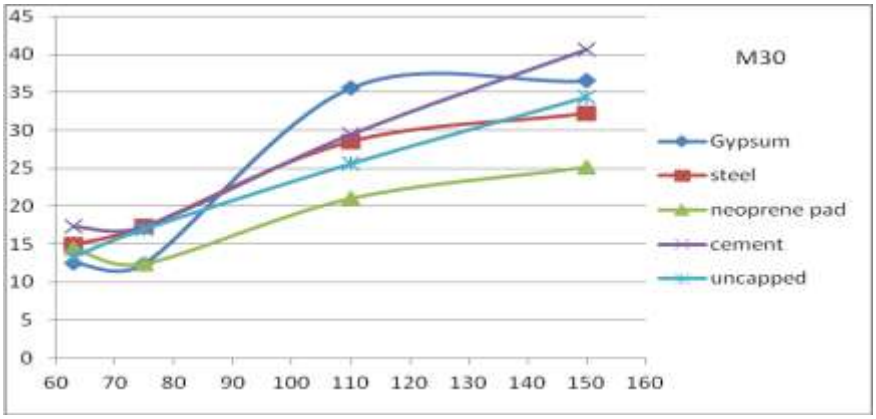
From this table we can say that Neoprene pad capping gives minimum compressive strength as compared to other capping and cement capping gives maximum compressive strenth for M15 and M30 grade but for M45 we can't say same. Graphs plotted between compressive strength and diameter, this graph show variation of strength of cylinders having different capping with changing diameter, taking grade constant.

For M15



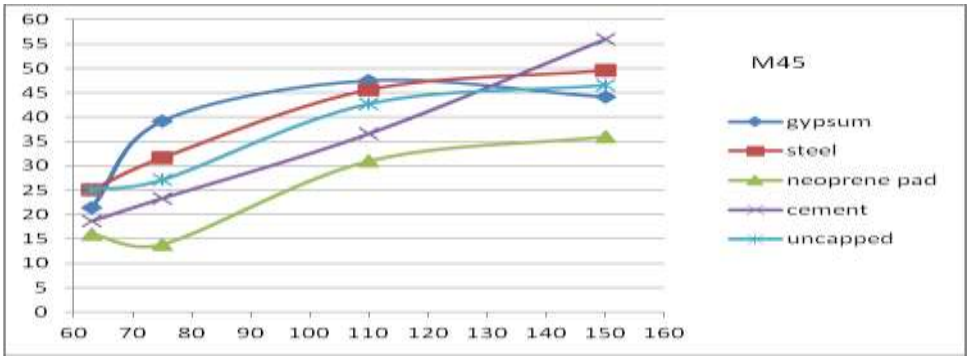
Here on X axis diameter of cylinder and on Y axis compressive strength of cylinder are taken From this graph we can say that neoprene pad giving least compressive strength when we use it as capping material, and cement gives maximum strength. From this graph we can say that cement capping having least curve almost it is linear.

For M30:



Here on X axis diameter of cylinder and on Y axis compressive strength of cylinder are taken From this graph we can say that compressive strength of cylinder which is capped by cement having maximum compressive strength and steel providing approximate equal strength as compared to other capping, hence we can use steel capping in place of uncapping.

For M45:



Here on X axis diameter of cylinder and on Y axis compressive strength of cylinder are taken In this grade also cement capping providing least compressive strength but Cement not providing maximum compressive strength for all diameter. And here also steel capping is best as it provide most accurate result as

compared to other as our control method is uncapped cylinder and steel having approx equal strength as uncapped.

IV. Conclusion

- Material properties such as strength, elastic modulus, bonding capacity are very important in selecting a suitable cap.
- Gypsum and cement requires significantly greater time and effort compared to other unbonding capping such as steel cap and neoprene pad capping.
- Cement capping providing maximum strength to concrete cylinders.
- Neoprene pad provide least strength when we use it as capping.
- Steel capping is best as our control method is uncapped and steel gives best and approx same result and least variation as compared to other.
- As the diameter of cylinder increases compressive strength of cylinder increase, same with grade also.
- Height increases strength increases.

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