Experimental Study on Paper Sludge as Cement Replacement in Cement Concrete

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Abstract— Waste paper sludge is waste product of paper industry, during manufacturing of paper white mud comes out during the process is called paper sludge or hypo sludge or brine sludge. This project is based on the viability of use of waste paper sludge, an industrial waste comes out during manufacturing of paper as partial replacement of cement in cement concrete. Concrete is widely used building material which is used all over the world. Cement which is used as a binding material in concrete contain silica, this cement release poisonous gages during hydration of cement and pollute environment. Although cement is also a costly material, using waste material as partial replacement of cement can save environment and also make concrete economical. Particular this study is based on utilization of paper sludge as partial replacement of cement in concrete, M30 and M40 concrete is manufactured which contains paper sludge 5% to 40% at interval of 5%. Concrete which contains waste paper is tested for compressive strength, flexural strength and split tensile strength, also slump cone test to check workability.

Key words: Paper Sludge, Workability, Compressive Strength, Flexural Strength, Cement, Fine Aggregate

I. Introduction

Concrete is one of the most widely used construction materials in the world. Many modifications and developments have been made to place industrial waste such as paper sludge on building construction. Utilization of waste materials for construction shall not only solve waste problems, but also provide a new source for construction purposes. The introduction of paper sludge as fine aggregates replacement materials in concrete seems to be successful recently. The use of paper sludge as a substitute for fine aggregates in concrete mix is one option that can alleviate sludge disposal problem. Research and development to convert paper sludge to useful application such as a construction material will provide more alternatives for the engineer to select the most suitable concrete replacement material for different environments. In this case, studies are needed to study the performance of concrete using paper sludge as fine aggregate as replacement materials.

In addition, the use of paper sludge as cement replacement materials in concrete is not common in the Indian construction sector. This study will be able to enhance the understanding on the suitability of paper sludge as cement replacement material.

Basic strength characteristics, such as compressive strength, splitting tensile strength, flexural strength, and density of concrete with paper sludge are the main focuses in this research. Strength is one of the most important property of concrete since the first consideration in structural design is that the structural elements must be capable of carrying the imposed loads. Furthermore, strength characteristic is also vital because it is related to several other important properties which are more difficult to measure directly.

According to this matter, the development of compressive strength, splitting tensile strength, flexural strength, and density of concrete are studied. The mixed of concrete used in this research is for grade M30 and M40 which is according to the Designs of concrete mix based on the IS 10262 : 2009. Based from results of the study, the most suitable mix proportion is the 0%, 5%,15% and 20% replacement of paper sludge to cement in concrete are studied. All the concrete specimens are cured by immersion in portable water at room temperature. Concrete tests are conducted on the concrete specimen at the specific ages. All the strength tests are limited to the ages of 7 and 28 days after production of the specimens. Besides, the physical properties of the waste material are also studied in this research.

II. Methodology

A. Selection of Materials

Portland pozzolana cement (fly ash based) is used, conforming to specification given under IS 1489: 1991 (Part –I) is used, properties of cement which obtained in laboratory i.e. fineness 3.82%, Initial setting & final setting time 41 & 197 minutes respectively, specific gravity is 3.14, soundness 2mm, compressive after 7 and 28 days of curing is 24.56 & 37.84 Mpa respectively. Conforming to IS 456, clean water is used for manufacturing of concrete. Natural sand is used as fine aggregate whose specific gravity is 2.60, bulking 24.23%, water absorption is 0.92%. natural crushed stone is used as coarse aggregate whose specific gravity is 2.62, crushing, impact, and abrasion value of aggregate is 14.90%, 11.21% and 12.54% respectively, water absorption obtained is 0.64%.

B. Mix design

M30 and M40 concrete mix is prepared for this study, total 10 mix of concrete is prepared 5 of M30 and M40 each containing waste paper sludge in different percentage. Mix design of these mix is done as per specification given under IS 10262 : 2009. Mix designation of M30 and M40 concrete is given below.

S.No.	Grade of Concrete	Content Paper Sludge in M30 Concrete	Mix Name
1	M30	0%	PSM1
2	M30	5%	PSM2
3	M30	10%	PSM3
4	M30	15%	PSM4
5	M30	20%	PSM5
6	M40	0%	PSQ1
7	M40	5%	PSQ2

8	M40	10%	PSQ3
9	M40	15%	PSQ4
10	M40	20%	PSQ5

Table 1: Mix designation of concrete

C. *Casting and Curing*

15 *15*15 cm concrete cube is casted for the compressive strength test and 15*15*70 cm beam is casted for flexural strength test and 15*30 cm cylinder is casted for split tensile strength. And curing is done in clear water in room temperature.

III. Result and Discussion

Table 2 and Table 3 shows the combined test result of M30 and M40 concrete.

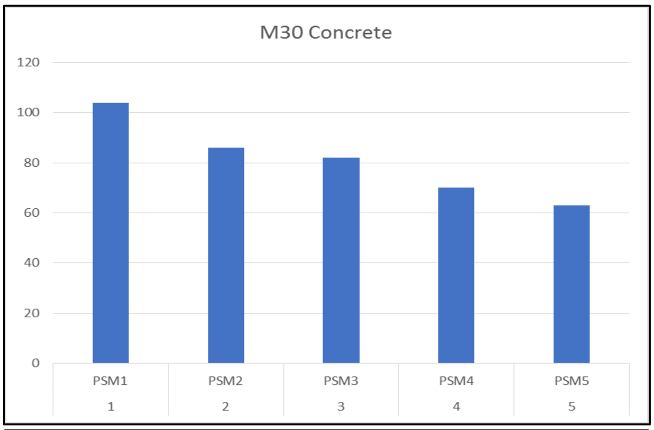
M30 Concrete						
S.No.	Mix Name	Compressive Strength (N/mm2)		Split Tensile Strength (N/mm2)	Flexural Strength (N/mm2)	Slump (mm)
		7 Days	28 Days	28 Days	28 Days	
1	PSM 1	24.3	40.25	4.50	2.70	104
2	PSM 2	33.5	47.35	4.90	2.94	86
3	PSM 3	30.85	45.82	4.80	2.88	82
4	PSM 4	26.9	41.36	4.55	2.74	70
5	PSM 5	20.25	31.69	3.98	2.40	63

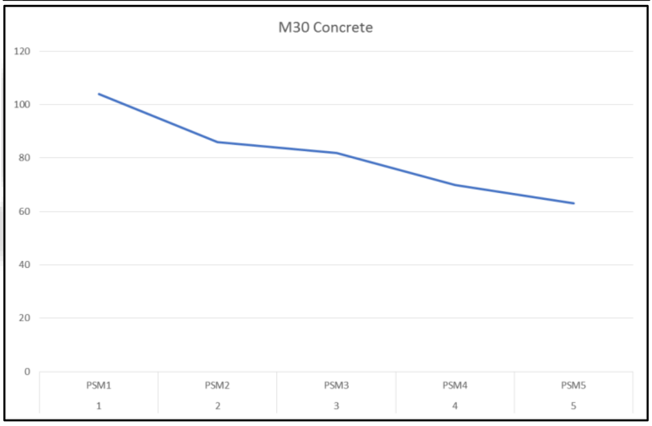
Table 2: Combined Test Results of M30 Concrete

M40 Concrete						
S.No.	Mix Name	Compressive Strength (N/mm2)		Split Tensile Strength (N/mm2) 28 Days	Flexural Strength (N/mm2) 28 Days	Slump (mm)
		7 Days	28 Days			
1	PSQ 1	34.7	51.1	5.10	3.05	96
2	PSQ 2	43.5	57.35	5.35	3.21	80
3	PSQ 3	41.75	56.54	5.30	3.18	73
4	PSQ 4	37.9	52.25	5.09	3.04	65
5	PSQ 5	30.65	43.51	4.70	2.78	60

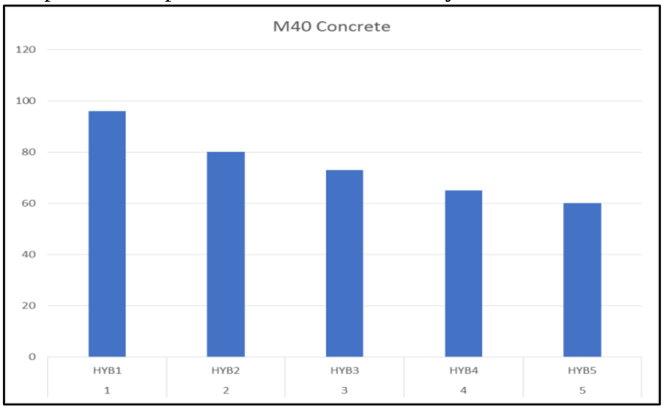
Table 3: Combined Test Results of M40 Concrete

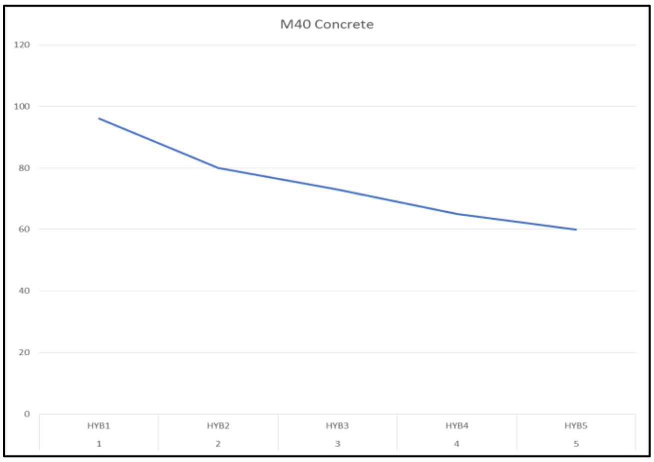
Workability of the concrete is evaluated by the slump cone test; slump of the concrete goes on decreasing when Paper Sludge is introduced in concrete as partial replacement of cement in concrete, test is conducted on M30 and M40 concrete and it has been observed that reduction in the workability of the concrete is noted. M30 PSM1 mix with 0% Paper Sludge gives 104 mm slump whereas its PSM3 mix with 5% Paper Sludge gives 86mm slump which goes on decreasing to attain 63 mm slump at 20% Paper Sludge (PSM5) mix. M40 PSQ1 mix with 0% Paper Sludge gives 96 mm slump whereas its PSQ3 mix with 5% Paper Sludge gives 80 mm slump which goes on decreasing to attain 60 mm slump at 20% Paper Sludge (PSQ5) mix. Graph 1-2 & 3-4 shows result of slump cone test on concrete.





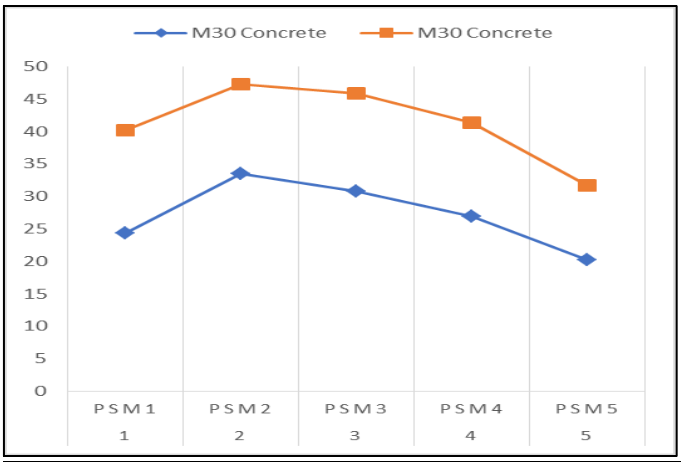
Graph 1 & Graph 2: Result of Workability of M30 Concrete

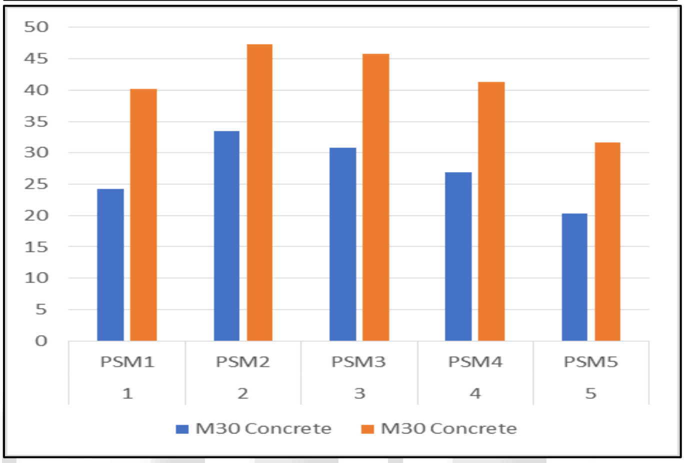




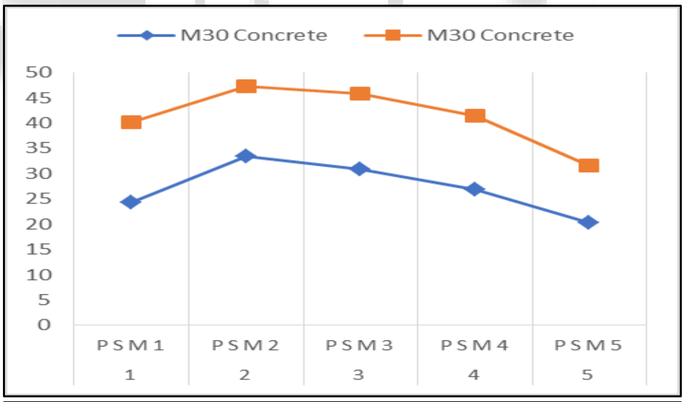
Graph 3 & Graph 4: Result of Workability of M40 Concrete

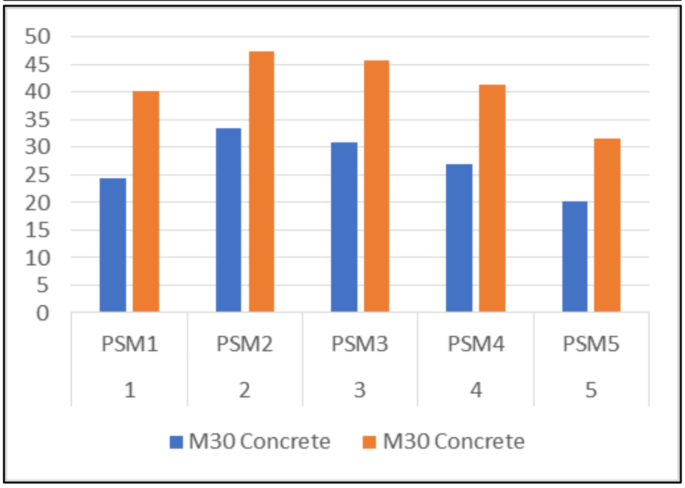
When Paper Sludge is partially replaced by cement in M30 and M40 concrete upto 20% at an interval 5%, its has been observed that Paper Sludge (M30 Paper Sludge mixes) increases the compressive strength of the concrete its 0% M30 concrete PSM1 mix possess 24.3 N/mm2 compressive strength 7 days of curing and 40.25 N/mm2 compressive strength after 28 days of curing, and it goes on increasing and attain 33.5 N/mm2 and 47.35 N/mm2 compressive strength after 7 and 28 days of curing respectively when 5% Paper Sludge is replaced by cement in concrete (PSM2), when 10% Paper Sludge is added in concrete (PSM3), result shows compressive is increased and reached to 30.85 N/mm2 and 45.82 N/mm2 after 7 and 28 days of curing, next two mix i.e. PSM4 and PSM5 mix in which cement is partially replaced by cement by 15% and 20% respectively, PSQ4 mixe possess compressive strength of 26.84 N/mm2 compressive strength after 7 days of curing 41.36 N/mm2 compressive strength 28 days of curing and PSM5 mix shows compressive strength of 20.25 N/mm2 and 31.69 N/mm2 after 7 and 28 days of curing respectively. Paper Sludge M40 mixes increases the compressive strength of the concrete its 0%, PSQ1 mix possess 34.7 N/mm2 compressive strength 7 days of curing and 51.1 N/mm2 compressive strength after 28 days of curing, and it goes on increasing and attain 43.5 N/mm2 and 57.35 N/mm2 compressive strength after 7 and 28 days of curing respectively when 5% Paper Sludge is replaced by cement in concrete (PSQ2), when 10% Paper Sludge is added in concrete (PSQ3), result shows compressive is increased and reached to 41.75 N/mm2 and 56.54 N/mm2 after 7 and 28 days of curing, next two mix i.e. PSQ4 and PSQ5 mix in which cement is partially replaced by cement by 15% and 20% respectively, PSQ4 mixes possess compressive strength of 37.9 N/mm2 compressive strength after 7 days of curing 52.25 N/mm2 compressive strength 28 days of curing and PSM5 mix shows compressive strength of 30.65 N/mm2 and 43.51 N/mm2 after 7 and 28 days of curing respectively. Graph 5-6 & 7-8 show result of compressive strength of concrete.

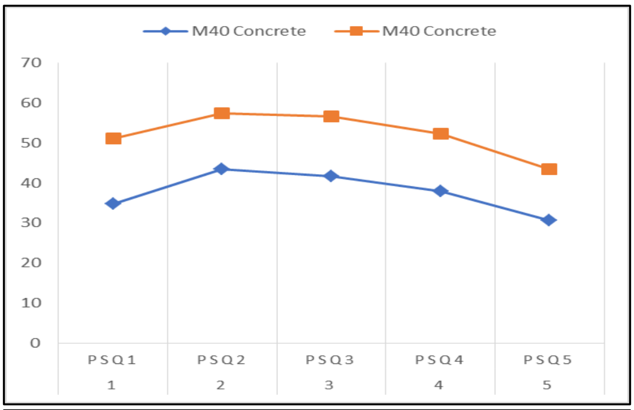


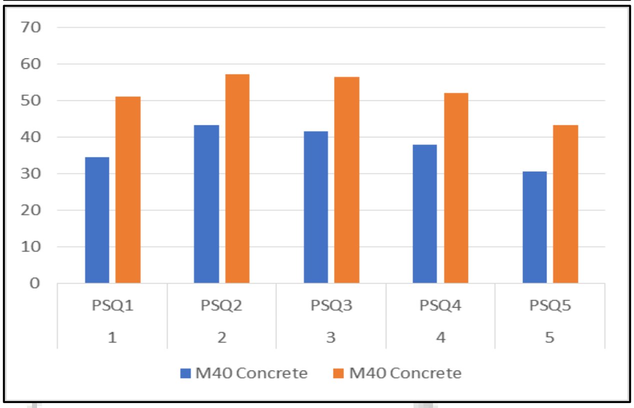


Graph 5 & Graph 6: Result of Compressive Strength of M30 Concrete





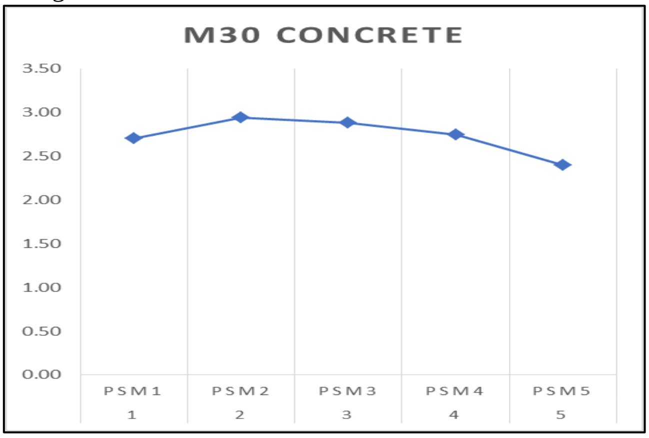


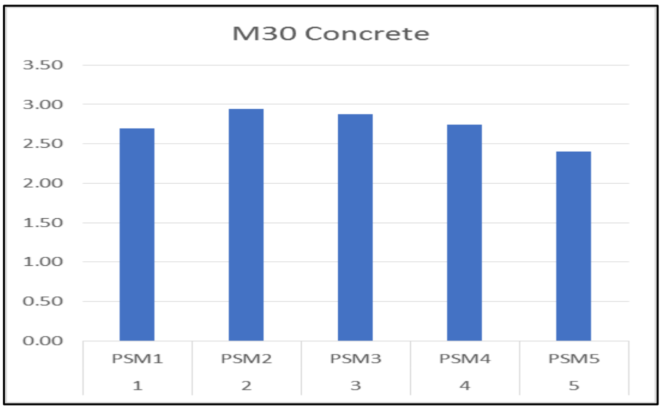


Graph 7 & Graph 8: Result of Compressive Strength of M40 Concrete

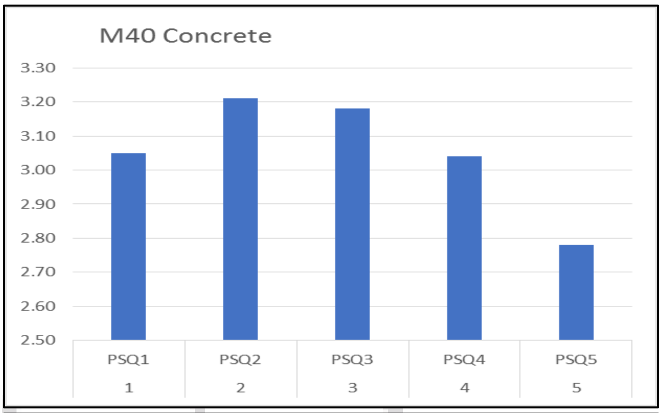
The flexural strength is determined by beam test, when Paper Sludge is used as binder material which can replace cement in concrete upto 20%. Test conducted on M30 and M40 concrete and result shows, increment in flexural strength of concrete upto 15% then decrement in flexural strength is observed. M30 mix of concrete containing Paper Sludge, PSM1 mix shows 2.70 N/mm2, which goes to 2.94 N/mm2 in PSM2 mix, PSM3 mix shows little decrement and posses flexural strength 2.88 N/mm2 and PSM4 and PSM5 mix posses flexural strength of 2.74 N/mm2 and 2.40 N/mm2 respectively.

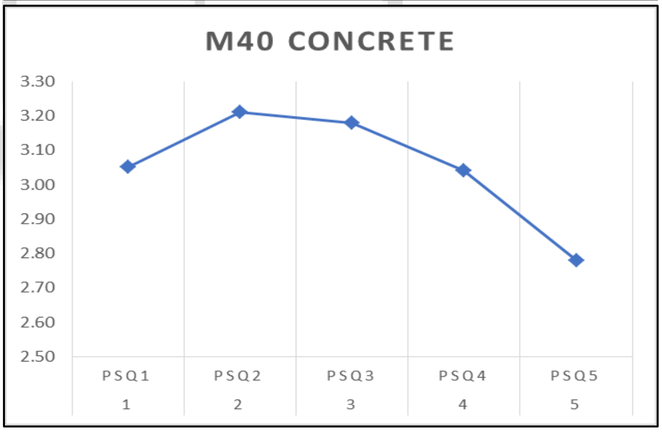
M40 mix of concrete containing Paper Sludge, PSQ1 mix shows 3.05 N/mm2, which goes to 3.21 N/mm2 in PSQ2 mix, PSQ3 mix shows little decrement and posses split tensile strength 3.18 N/mm2 and PSQ4 and PSQ5 mix posses split tensile strength of 3.04 N/mm2 and 2.78 N/mm2 respectively. Graph 9-10 & 11-12 show result of flexural strength of concrete.





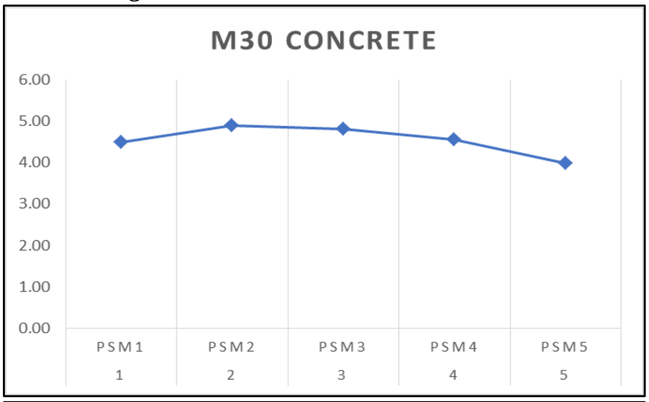
Graph 9 & Graph 10: Result of Flexural Strength of M30 Concrete

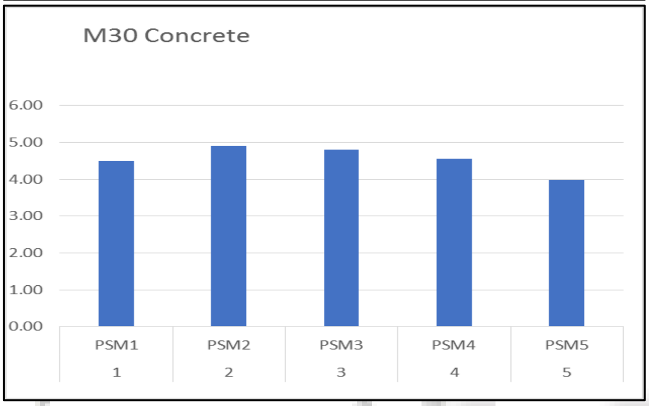




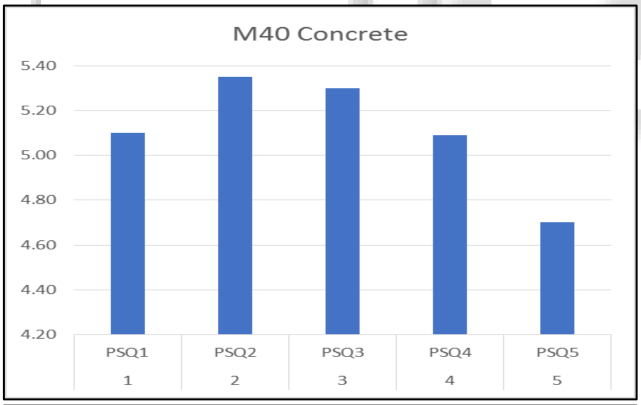
Graph 11 & Graph 12: Result of Compressive Strength of M40 Concrete

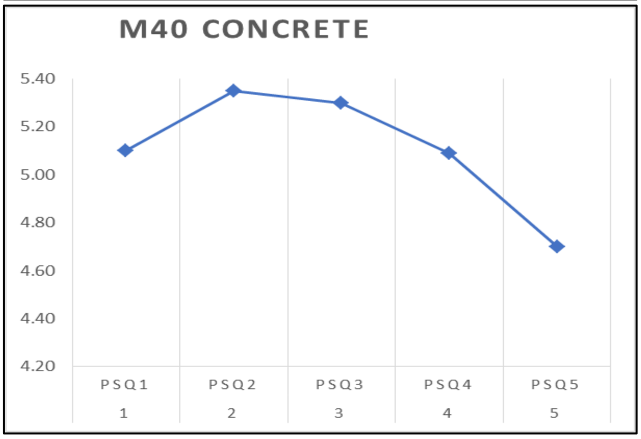
The split tensile strength is determined by split tensile test, when Paper Sludge is used as binder material which can replace cement in concrete upto 20%. Test conducted on M30 and M40 concrete and result shows, increment in split tensile strength of concrete upto 15% then decrement in split tensile strength is observed. M30 mix of concrete containing Paper Sludge, PSM1 mix shows 4.50 N/mm2, which goes to 4.90 N/mm2 in PSM2 mix, PSM3 mix shows little decrement and posses split tensile strength 4.80 N/mm2 and PSM4 and PSM5 mix posses split tensile strength of 4.55 N/mm2 and 3.98 N/mm2 respectively. M40 mix of concrete containing Paper Sludge, PSQ1 mix shows 5.10 N/mm2, which goes to 5.35 N/mm2 in PSQ2 mix, PSQ3 mix shows little decrement and posses split tensile strength 5.30 N/mm2 and PSQ4 and PSQ5 mix posses split tensile strength of 5.09 N/mm2 and 4.70 N/mm2 respectively. Graph 13-14 & 15-16 show result of split tensile strength of concrete.





Graph 13 & Graph 14: Result of Split Tensile Strength of M30 Concrete





Graph 15 & Graph 16: Result of Split Tensile Strength of M40 Concrete

IV. CONCLUSION

Waste paper sludge is added in concrete at different percentage and properties of concrete is evaluated, Study are meted out on the M30 and M40 concrete, wherever test like slump cone is performed on fresh concrete and compressive strength, flexural strength and split tensile strength test on hardened concrete is performed. Study clearly shows that workability of the concrete is decreased when percentage of Paper Sludge is increased in concrete in each M30 and M40 concrete. Study also shows that Paper Sludge needed a lot of water content in concrete, so superplasticizer may be added in concrete to scale back the required water content of the Paper Sludge in concrete. On the idea of various test performed on hardened concrete like compressive strength, flexural strength and split tensile strength, study shows that compressive strength and different two strength show increment when Paper Sludge is added in concrete, it's been determined five percent is that the optimum proportion for the cement replacement in the concrete and conjointly upto 15% Paper Sludge can replace cement in concrete because when hypo replace cement upto 15% in concrete, these mix posses higher result than conventional concrete that contains 0% Paper Sludge.

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