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Ternary Effects on Cement Blends of Self Compacting Concrete Containing Nano Silica, Metakaolin, Fly Ash

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Abstract:

The paper presented herein the investigates the effect on the Self-Compacting Concrete(SCC) incorporated with supplementary cementitious materials as ternary blends. For this purpose, three supplementary materials are used Fly Ash, Nano Silica and Metakaolin.Ordinary Portland Cement act as controlled mix binder while the remaining mixtures are incorporated ternary blends of OPC, Metakaoline, Fly ash and Nano Silica. The supplementary blends are taken at a range for Fly Ash 10%,20%,30%,40% for nano silica constantly kept at 3% and Metakaoline are taken as 5%,10% and 15% with the binder content. The water cement ratio kept as 0.4.Super Plasticizer is include the concrete mixture to improve the workability. After Mixing the fresh concrete mixture were tested for slump flow, L-Box Test and V-funnel test. Most importantly compressive, split tensile and flexure test of the hardened concrete were measure at 7 and 28 days. The test results investigates the effective increment of mechanical properties with the ternary blends and achieving the standard properties of SCC.

Keywords*: SCC, Fly Ash, Metakaolin, Nano Silica, super plasticizer, compressive strength, split tensile strength, flexure strength*

1. INTRODUCTION

Concrete is the most widely used material for all the construction works. It is a combination of cementitiousmaterial,fine and coarse aggregate ,water and admixtures to improve the properties of concrete.Self Compacting conctere is the property of concrete to compact on its own weight without the use of vibrator for doing so.It is used in mass concrete construction areas where more labour and material used.Its avoids the time consumptions and reduce the noise generated due to vibrators.At joint by using SCC to avoid the failure of structure. At the same time self compacting concrete requires less labours.Super plasticizer should needed the workability of concrete. Fly ash is a byproduct of thermal coal from thermal power plant gives the improvement of strength at later stages at less

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cost.Nano silica is the hydrated form of by carbonate products to improve the pore filling and permeability properties of concrete.Metakaoline having the effect on concrete at later ages to increase its strength properties.Conplast SP430 is used as super plasticizers to improve the workability of SCC.When the cement get replaced with the waste cementitious products the cost is low and environmental friendly too.

2. LITERATURE REVIEW

AsmaAbdElhameed Hussein et al. (**2013),** Fly ash is the main contributor for the study.Fly ash upto 50% was replaced with cement .The results shows that upto 30% of fly ash contribution gives the major strength improvement than the conventional concrete.

R.Madandoust et al. (2013) ., This involves concrete mixture made with 20% replacement of metakaolin and zeolite give the compressive strength is decreased at early age. But at later age the compressive strength is increased both in metakaolin and zeolite.water penetration in zeolite is decreased at later age. but in metakaolin the water penetration is decreased at early age. Both are beneficial effects in durable properties.

Elsayed A.A. (2012), Analysed the influence of admixtures on the waterpercolationand strength of concretes which contain Fly Ash And Silica Fume, Super Plasticizers (SP) were experimentally investigated. They were replaced into concrete silica Fume at the levels of 5%, 10%, 15% and Fly Ash 10%, 20%, 30%, and super plasticizers by weight of cement. W/C 0.40 was used and tested at 28 days. From the test better permeability results at 10% SP 20% Fly Ash and 10% Silica Fume content. Higher compressive strength obtain at 15% of silica fume content above that the results getting decreased. High slag contributes the major improvement in permeability and strength on concrete.

Sanjay et_al (2012),.The usage of metakaolin which gives good pozzolanic activity , and gives high strength concrete. The optimal is found by replacing upto 15% of the cement with metakaolin. The compressive strength of concrete increased by 20%. With the 15% of metakaolin decrease the workability of suspension in time. Increasing amount of metakaolin in concrete is require higher dosage of superplasticizer to ensure longer workability.

Heba A. Mohamed. (2011).,SelfCompactingConcrete (SCC) with two cement content. Study with the three cementitious material cement, Fly ash, silica fume. The workability and strength are checked with the material individualy as wel as combine concrete.The results shows that at 15% silica fume gives better results than 30% of Fly ash content.

Khanzadi M et_al (2010), Investigate the strength properties of concrete with inclusion of Nano silica. Results shows that a nano particle gives the strength improvement compare to conventional concrete.

3. OBJECTIVES

- It is aimed to carry the literature study related to research works on utilization of pozzalonic materials and by products inconcrete, to minimize environmental problems and demand of aggregate and cement.
- To obtain the optimum amount of waste material in concrete can determined by Conducting different fresh concrete and hardened concrete tests.
- Effective use of ternary materials in cementconcrete.
- To reduced the cost of the cement by using the natural materials and protect the environment from pollution by reduction of CO2.
- To check the strength and durability properties of cement concrete.

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- To evaluate the Mechanical properties of cement concrete produced with various ratio were evaluated.

4. MIX DESIGN FOR M25 GRADE CONCRETE

Mix design is the process of deriving the proportions which gives the required strength on concrete. In this present study we use M25grade.

4.1 DESIGN STIPULATIONS

Mix proportioning is the process of providing the mix on concrete. The mix proportion for M25 grade concrete for our requirement is as follows:

Table -1 characteristics of a concrete mixture.

Concrete Grade	M25
Compressive strength on concrete at 28 days	25 N/mm²
size of aggregate	12mm
Degree of workability	650mm (slump value)
Degree of control	Good
Type of exposure	Mild

4.3MIX DESIGN

The mix used for this study per unit volume of concrete are as follows

Table-2 Volume of concrete per unit length

Target mean strength	31.56N/mm²
W/C ratio	0.40
Weight of cement	1100kg/m³
Weight of water	440kg/m³
Weight of fine aggregate	1100kg/m³
Weight of coarse aggregate	2200kg/m³

4.4 MIX PROPORTION

The mix proportion used for the present study is follows.

Table-3 Mix proportion of concrete

Water	Cement	fine aggregate	coarse aggregate	S.P
0.4	**1**	**1**	**2**	**0.5%**

5. SPECIMEN IDENTIFICATION

The various specimen cast are shown in below table.

Table-4.Specimen Identification

Mix	Definition
S0	Conventional concrete
S-1	cement+10% fly ash+3%nano silica+5%metakaoline as a binder
S-2	cement+20% fly ash+3%nano silica+5%metakaoline as a binder
S-3	cement+30% fly ash+3%nano silica+5%metakaoline as a binder
S-4	cement+40% fly ash+3%nano silica+5%metakaoline as a binder
S-5	cement+10% fly ash+3%nano silica+10%metakaoline as a binder

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S-6	cement+20% fly ash+3%nano silica+10%metakaoline as a binder
S-7	cement+30% fly ash+3%nano silica+10%metakaoline as a binder
S-8	cement+40% fly ash+3%nano silica+10%metakaoline as a binder
S-9	cement+10% fly ash+3%nano silica+15%metakaoline as a binder
S-10	cement+20% fly ash+3%nano silica+15%metakaoline as a binder
S-11	cement+30% fly ash+3%nano silica+15%metakaoline as a binder
S-12	cement+40% fly ash+3%nano silica+15%metakaoline as a binder

6. TEST ON FRESH CONCRETE

6.1 FRESH CONCRETE PROPERTY

To determine the quality of materials and strength characteristics we need to do for fresh concrete test. It helps to confirm the concrete used to develop the required strength.

6.2 TESTS FOR FRESH CONCRETE

1. Slump test 2. L-box test 3.V-Funnel test

6.2.1 SLUMP FLOW TEST

It is used most commonly for determining the filling ability of concrete. The flow value determine in term of measuring the flow diameter.

Fig- 1 Testing of Slump flow test

6.2.2 L-BOX TEST

This method is used to measure the filling and passing ability of concrete. The apparatus consist of L shape rectangular box with both direction gates.

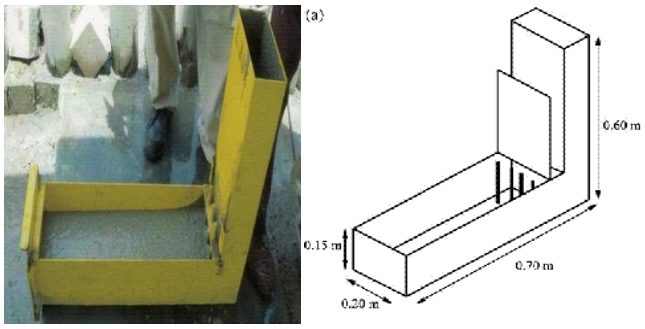

Fig- 2 Testing of L- BOX

6.2.3 V-FUNNEL TEST

For determine the filling ability of concrete this test is used to done. If the segregation of concrete is high the corresponding flow time also increases.

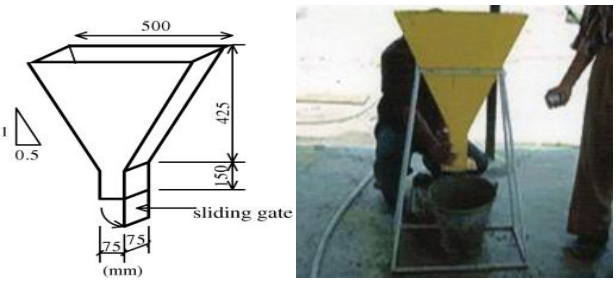

Fig- 3 Testing of V-Funnel

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7. TEST ON HARDENED CONCRETE

7.1 HARDENEND CONCRETE PROPERTY

To confirm the strength and durability of concrete we are required to do harden concrete test.

7.2 TESTS FOR HARDENED CONCRETE

1.Compression strengthTest 2.Split Tensile Test 3.Flexural strengthTest

7.2.1 CUBE COMPRESSION TEST

The ability of concrete against the applied load in vertical direction compression testing is used. The cube casted was 150mm in size. The characteristic strength was determined at 28 days. Compressive testing machine was used to determine the ability of concrete to resist against normal loading. This test results shows the overall quality of the concrete.

Compressive strength, C = P/A

Where,

P = load (N)

A = area of cube (mm^2)

Fig- 4 Testing of Compressive strength test

7.2.2 SPLIT TENSILE STRENGTH OF CONCRETE

This is the important test of concrete against its lateral loading. The specimen casted in the form of cylinder having dimension of 150 in diameter and 300mm in length. Itsa indirect method of finding tensile strength on concrete at 7 & 28 days.

Tensile strength = 2P/πDL

Where,

P is the applied load (N)

D and L are the diameter and the length of the specimen

Fig-5 Testing of Split tensile strength test

7.2.3 FLEXURAL STRENGTH OF CONCRETE

The resistance against bending is called as flexure strength. The specimen used this study is prism having dimension of 500mm*100mm*100mm. Two point loading is given this present study. The test results was taken at 7 & 28 days.

Flexural Strength= PL/BD^2

Where

P is the applied load

L,B& D is the length, breath and diameter of prism.

8. RESULTS AND DISCUSSION

8.1 SLUMP FLOW OF CONCRETE

Table-5.Slump Flow Values

Specimen name	Slump Value (mm)
S0	680
S1	660
S2	720
S3	740

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S4	710
S5	690
S6	700
S7	702
S8	684
S9	652
S10	703
S11	667
S12	738

8.2 L-BOX TEST ON CONCRETE

Table-6.L-Box test Values

Specimen Name	H1/H2 Ratio
S 0	0.89
S 1	0.81
S 2	0.85
S 3	0.91
S 4	0.94
S 5	0.96
S 6	0.82
S 7	0.79
S 8	0.83
S 9	0.87
S 10	0.84
S 11	0.77
S 12	0.93

8.3 V-FUNNEL TEST ON CONCRETE

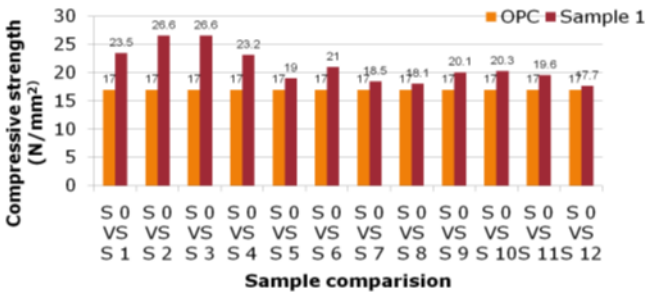
Table-7 V-Funnel test Values

Specimen Name	Time (sec)
S 0	9
S 1	8
S 2	9
S 3	10
S 4	10
S 5	11
S 6	11
S 7	12
S 8	10
S 9	9
S 10	10
S 11	11
S 12	12

The slump flow test, L-Box Test and V-Funnel Test values shows that the Self Compacting concrete is achieved by the results satisfies as per the guideline EFNARC.As per the guideline .This shows the SCC is achieved for all the ternary blend concrete. So the workability, passing ability and filling ability of concrete with the replacement of ternary blends doesn't affect the formation of Self Compacting Concrete.

8.4 COMPRESSIVE STRENGTH OF CONCRETE

The compressive, split tensile strength results at 7 & 28 days



Graph-1 Compressive Strength after 7 days curing

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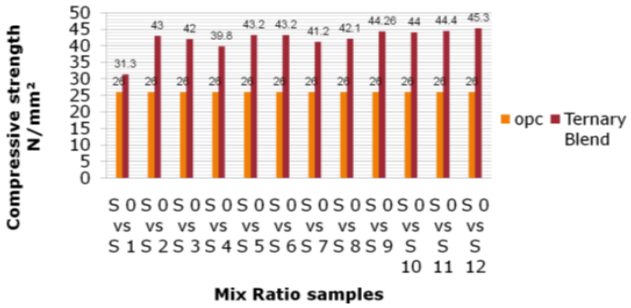
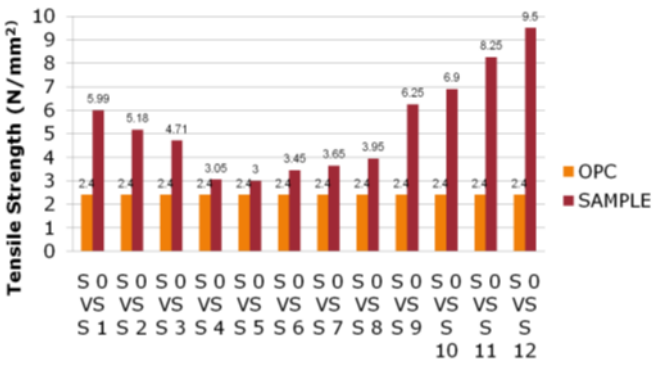


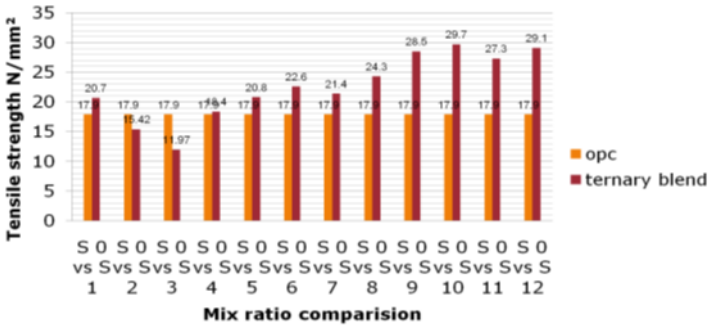
Graph- 2 Compressive Strength after 28 days curing

The test results of self compacting concrete with the ternary blends were compared with the conventional concrete specimens. It is observed that when compared to control specimens, all the ternary blend materials are replaced with the cement display a higher strength than the control specimen at both 7th and 28th day. At the end of 28th days there was 4.4% increase in compressive strength. The overall best mix specimen was achieved in the concrete sample with the 40% fly ash,3%Nano silica and 15% Metakaoline ternary blended and replaced with the cement. This indicates that the materials replaced with the binder had no ill effects on the concrete samples used. Compressive strength in the Self Compacting Concrete samples has a significant property over the normal concrete. And the higher amount of replacement gives a maximum result this also gives the reduction of cost and environmental effective too.

8.5 SPLIT TENSILE STRENGTH OF CONCRETE



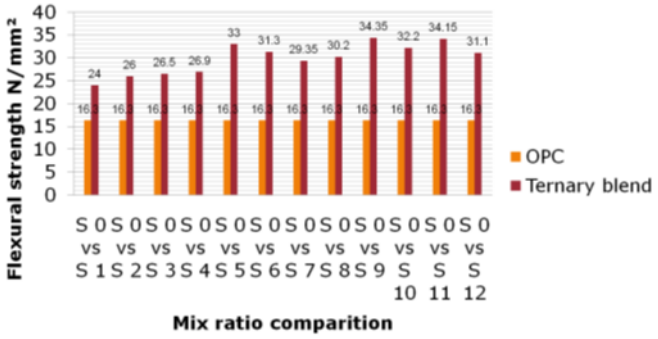
Graph-3 Split Tensile Strength after 7 days curing



Graph-4 Split Tensile Strength after 28 days curing

From the results of the strength tests shows the above figure, the figure is evident that considering the replacement of pozollanic material, the tensile strength test results at the age of 28 days are shown in Figure-3. According to Figure-3, it In case of the higher amount of ternary material replacement with the concrete by 55%, it yields maximum improvement in strength about 0.7 % when compared with control specimen. All the materials replaced with the specimens display a higher strength than the control specimen. It could be the Significant reactions hardening effect of the self compacting concrete.

8.6 FLEXURAL STRENGTH OF CONCRETE



Graph-5 Flexural Strength after 28 days curing

CONCLUSION

- Result shows that the significant effect of Self compacting concrete with the replacement of ternary blend materials.
- It proves the waste materials can be used to achieve self-compacting concrete.

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- The result is increase in each and every Replacement percentage up to 55% of ternary blend with the cement gives rapid increments of strength properties of concrete.
- When early ages even at 7 days the SCC achieve its target strength. This shows the effective reaction of three blended materials with the OPC.
- All the fresh concrete test satisfies the Specified standard values given in the EFNARC guidelines.
- The result of Compressive, tensile and flexural test results increase rapid rate so the materials replacement can be possible more than 50% this helps to reduce the cost, enviroinment pollution and time to work at SCC than the normal concrete.

CONFLICT OF INTEREST STATEMENT:

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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