International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-6, March 2020

Mechanical Properties of Fly Ash Based Geopolymer Concrete and Conventional Concrete

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Abstract: ***Creation of concrete includes devouring of common non-sustainable assets. The concrete ventures have been ordered as profoundly dirtying enterprises. It is relevant to utilize eco-accommodating strategies in a manner to supplant, lessen or reuse the customary materials to be utilized in cements (Portland Cement Concrete). Solid utilization is underdog to water right now. Normal Portland concrete is ordinarily utilized as basically fastener to create concrete because of its accessibility of the crude materials everywhere throughout the world. The use of cement has extraordinarily affected the cutting edge world in framework, home and transportation, advancing the improvement of monetary advancement, human advancement and personal satisfaction. The natural issues related with the creation of OPC is notable, the measure of carbon dioxide discharged during the production of OPC because of calcinations of limestone and ignition of non-renewable energy sources is high. It is well kwon truth that creation of 1 kg of concretes delivers almost 1 kg of carbon dioxide. The degree of vitality required to deliver OPC is just beside steel and Aluminum so there is a need to conserve concrete. One of the solid answers for conserve concrete is to supplant with other strengthening establishing materials like fly debris, slag, meta kaolin, and so on then again the bottomless accessibility of fly debris, which being a side-effect of coal-based force plants the world over making a chance to enhance to OPC with fly debris. The all out creation of fly debris is almost as same as concrete, however our use of fly debris is just 5% of the creation, subsequently the utilization of fly debris ought to be improved.***

Keywords **:** ***Fly ash based Geopolymer, conventional concrete materials, fossil fuels, supplementary cementing materials like fly ash, slag, meta kaolin etc***

I. INTRODUCTION

The ecological issues related with the creation of OPC is notable, the measure of carbon dioxide discharged during the assembling of OPC because of calcinations of limestone and burning of non-renewable energy sources is exceptionally high. It is well kwon reality that creation of 1 kg of concretes delivers about 1 kg of carbon dioxide.

Manuscript received on February 10, 2020.
Revised Manuscript received on February 20, 2020.
Manuscript published on March 30, 2020.
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The degree of vitality required to create OPC is just beside steel and Aluminum so there is a need to streamline concrete. One of the solid answers for streamline concrete is to supplant with other advantageous solidifying materials like fly debris, slag, meta kaolin, and so on then again the rich accessibility of fly debris, which being a result of coal-based influence plants the world over making a chance to enhance to OPC with fly debris. The absolute creation of fly debris is almost as same as concrete, however our use of fly debris is just 5% of the creation, consequently the use of fly debris ought to be improved.One of the numerous options in feasible techniques is to mix materials with cement, for example, modern squanders/side-effects. Antacid initiation of slag, fly debris (FA), consumed dirt and other alumina-silicate materials is one such eco-accommodating option in contrast to regular cement. The crude material utilized for salt initiation is Fly debris. In the present examination the solidified properties of soluble base initiated fly debris based geo-polymer concrete with sodium silicate as activator and customary cement (PCC) is being thought about. Many research works have been done on geo-polymer solid utilizing basic arrangement, which is the mix of sodium silicate and sodium hydroxide, yet the takes a shot at supplanting 100% of concrete with soluble base enacted fly debris utilizing antacid arrangement are uncommon. This cover material can supplant Portland concrete; by soluble base enactment it can create around 80–90% less carbon dioxide than that of Portland concrete. Contrasting with Portland concrete cement, the an Earth-wide temperature boost capability of soluble base actuated cement is 70% lower. Salt enacted materials have been utilized as elective folios offering points of interest regarding mechanical quality, synthetic sturdiness, warm opposition

1.1 Research significance:

Creation of Portland concrete cement mitigates the air quality, discharging a lot of carbon dioxide into the air causing nursery impact and causing an assortment of ecological issues, these natural issues messes' wellbeing up thusly influencing the personal satisfaction. As there is an exponential development of populace, there is an ever-developing interest for foundation. For addressing the necessities of the expanding populace there will be an enormous prerequisite of concrete, yet as we have seen they are not a practical and an ecologically benevolent material. Right now attempt to show an elective material which is reasonable and earth inviting, the material utilized is fly debris which totally replaces concrete and the water is supplanted with sodium silicate arrangement, having silica modulus (Ms) of 1.99. The intend to give a material that not exclusively is ecologically benevolent yet in addition acts similarly or shockingly better than concrete cement and is likewise practical.

The exploration information displayed is helpful to comprehend the designing properties of geo-polymer concrete, in light of salt enacted characteristic pozzolana.

1.2 Geopolymers

The term geopolymer was first acquainted by Davidovits in 1978 with portray a group of mineral folios with synthetic piece like zeolites yet with an undefined miniaturized scale structure. In contrast to Portland or pozzolana concrete, geopolymers don't frame calcium-silicate-hydrates (C-S-H) for grid arrangement and quality, yet use the polycondensation of silica and alumina forerunners to achieve auxiliary quality. Two principle constituents of geopolymers are: source materials and soluble fluids. The source materials for alumina silicate ought to be wealthy in silicon (Si) and aluminum (Al). The source materials could be by item materials, for example, fly debris, slag, silica seethe, rice husk debris, red mud, and so forth geopolymers are additionally interesting in contrast with other alumina-silicate materials.

1.3Alkali Activation

Soluble base initiation is a significant parameter in expanding disintegration of the beginning materials and offers ascend to great mechanical properties..

Fig 1. Descriptive model of the alkali activation of fly ash

Alkali actuation of alumino-silicate materials speaks to an intricate procedure that has not been depicted without limit yet. The response of alumino-silicate materials in a solid basic condition results, most importantly, in a breakdown of Si-O-Si bonds; later, new stages emerge and the system of their arrangement is by all accounts a procedure that incorporates an answer ("combination by means of arrangement"). The infiltration of Al molecules into the first Si-O-Si structure speaks to a significant component of this response. Alumino-silicate gels (geopolymer forerunners) are for the most part framed. Their sythesis can be described by the equation Mn [-(Si-O)z - Al–O]n. wH2O. The C-S-H and C-A-H stages may likewise be begun in reliance on the sythesis of the beginning materials and the states of the response. Indeed, even auxiliary H2O might be shaped during these (poly-buildup) responses. Formless (gel-like) or somewhat indistinct or crystalline substances might be begun in reliance on the character of beginning crude materials and on the states of the response. The convergence of the strong issue assumes a generous job during the time spent antacid initiation

1.4 Geopolymerisation

The geo polymerization process includes a generously quick compound response under soluble condition on Si-Al minerals that bring about a three-dimensional polymeric chain and ring structure comprising of Si-O-Al-O bonds, as follows:

Mn [-(SiO2) z-AlO2] n. wH2O

Where M= the antacid component or cation, for example, potassium, sodium or calcium

n = the level of poly buildup or polymerization

z = 1, 2, 3 or higher

II. LITERATURE REVIEW

N A Lloyd and B V Rangan,(2010)

They had contemplated geopolymer concrete with fly debris, in their work they had examined geopolymer concrete by considering various parameters like grouping of NaOH ,sodium silicate answer for sodium hydroxide arrangement proportion by mass, and so on, they had considered another term called "water to geopolymer solids" as the test parameter and Tests were performed to set up the impact of water-to-geopolymer solids proportion by mass on the compressive quality and the functionality of geopolymer concrete. The test examples were 100 x 200 mm chambers, heat-restored in a stove at different temperatures for 24 hours

Benjamin C. McLellan, Ross P. Williams, Janine Lay, Arie van Riessen, Glen D. Corder,(2011)

This paper shows that there is incredible potential for geopolymers to decrease the environmental change effects of concrete creation. For the proposed "regular" Australian geopolymer item, there is an expected 44-64% improvement in ozone depleting substance emanations over OPC, while the expense of these geopolymers can be up to twice as high as OPC. Nonetheless, the paper additionally shows that those advantages are just feasible given the most suitable wellspring of feedstock and the least cost transportation

Djwantorohardjito, Steenie E. Wallah, Dody M. J. Sumajouw, And B.Vijayarangan,(2004)

This paper introduced the improvement of geopolymer concrete. The folio right now, geopolymer glue, is shaped by enacting result materials, for example, low-calcium fly debris, that are wealthy in silicon and aluminum. In view of the trial work announced right now, following ends are drawn:

a) Higher centralization of sodium hydroxide arrangement brings about a higher compressive quality of geopolymer concrete..

b) Higher the proportion of sodium silicate-to-sodium hydroxide fluid proportion by mass, higher is the compressive quality of geopolymer concrete. c) Longer restoring time, (in the scope of 6 to 96 h/4 days), produces bigger compressive quality of geopolymer concrete. Be that as it may, the expansion in quality past 48 h isn't noteworthy

The geopolymer concrete experiences next to no drying shrinkage and low wet blanket. The obstruction of geopolymer concrete against sodium sulfate is amazing. They additionally cast geopolymer concrete precast items like railroad sleepers and box courses and so forth and were tried for load bearing quality in a heap testing machine which had a limit of 370 kN and worked to Australian Standards, load applied with the goal that the confirmation heap of 125 kN was come to in a short time. After the use of the confirmation load, the duct was inspected for splits utilizing a break estimating measure. The deliberate width of breaks didn't surpass 0.08 mm

T. Bakharev, (1994)

This paper reports the aftereffects of the investigation of the impact of raised temperature relieving on stage organization, microstructure and quality improvement in geo-polymer materials arranged utilizing Class F fly debris and sodium silicate and sodium hydroxide arrangements. Specifically, the impact of capacity at room temperature before the utilization of warmth on quality advancement and stage synthesis was considered. Long obtaining at room temperature before utilization of warmth was gainful for quality advancement in totally examined materials, as quality equivalent to multi month of relieving at raised temperature can create right now after 24 h of warmth restoring. The principle result of response in the geopolymeric materials was shapeless antacid alumino silicate gel

Ramin Hosseini Kupaei, U.JohnsonAlengaram, MohdZamin Bin Jumaat,(2013)

Common Portland concrete (OPC) is customarily utilized as the essential folio to deliver concrete. The natural issues related with the creation of OPC are notable. Fasteners could be created by a polymeric response of basic fluids with the silicon and the aluminum in source materials of topographical root or side-effect materials, for example, fly debris. Low-calcium fly debris based geopolymer is utilized as the fastener, rather than Portland or other pressure driven concrete glue, to create concrete. The production of geopolymer concrete is done utilizing the standard solid innovation techniques. As on account of OPC concrete, the totals possess around 75-80 % by mass in geopolymer concrete

The silicon and the aluminum in the fly debris respond with an antacid fluid that is a blend of sodium silicate and sodium hydroxide answers for structure the geopolymer glue. Geopolymerisation in fly-debris based cement could be happening by utilizing various arrangements with the answer for fly debris proportion by mass of 0.25 to 0.30. The best compressive quality will be more than 60 MPa for blends that utilized a mix of sodium hydroxide and sodium silicate arrangement, in the wake of relieving the examples for 24 hours at 650C. The extent of antacid answer for alumino-silicate powder by mass ought to be around 0.33 to permit the geo polymeric responses to happen. . By the utilization of the mass proportion of the answer for the powder of about 0.39 and blending 57% fly debris in with 15% kaolin or calcimined kaolin and the soluble fluid involve 3.5% sodium silicate, 20% water and 4% sodium or potassium hydroxide the most extreme compressive quality will be 75 MPa.

G.B. Maranan et al,(2015)

They had contemplated the flexural quality and workable attributes of GPC bars furnished with glass-fiber-fortified polymer were tried under a four-point static twisting test. The shifted parameters were breadth of the bars, level of fortification, and harbor framework. The displayed outcomes show that usefulness execution of a bar was improved however no noteworthy impact on flexural execution when changing bar width of the shafts

III. EXPERIMENTAL SETUP

In view of the broad writing survey an endeavor has been made to tentatively confirm the solid chance of planning low calcium (ASTM CLASS F) fly debris based geopolymer concrete for its reasonability to structural designing works.

3.1 Experimental programme

The exploratory investigation comprised of throwing and testing of 15 shapes of size 150x150x150mm, 3 crystals of size 100 x 100 x 500mm and 2 light emissions 100x200x1800mm for looking at the mechanical properties of GPC 20 and PCC 20. Similarly comparative test examples were readied utilizing Portland concrete cement for getting examination of results. In the First Phase, 15 3D shapes of GPC were thrown and tried occasionally for acquiring quality at 7,14 and 28th day. In the second stage 3 crystals of GPC were thrown and tried. Also, in third stage 2 bars were thrown and these examples were tried following 28 days relieving and the flexure conduct of the GPC and PCC was gotten.

3.2 Materials

The materials utilized right now Cement, fly debris, fine total, coarse total and sodium silicate arrangement.

3.3 Cement

Ordinary Portland Cement (OPC) grade 53 is used for production of PCC conforming to IS:12269-2013

3.4 Fly Ash

Right now an endeavor is made to create geo-polymer solid examples comprising calcined source materials and antacid fluids

3.5 Fine Aggregate and Coarse Aggregate

Zone-2 sand was considered for work and the physical properties of zone-2, fine total was appeared in table and Machine squashed stone utilized as coarse total. The size of total changes from 20mm to 4.75mm.

3.6 Alkaline Solution

The Sodium silicate utilized for soluble initiation in the present examination has a silica modulus of SiO2:Na2O (MS) = 1.99 with 24.88 % SiO2, 12.46 % Na2O by weight which has secured from KIRAN GLOBAL Ltd. Chennai, India

3.7 Moulds

For the assurance of compressive quality 3D shapes of 150×150×150mm size were utilized. Crystals of 100×100×500mm size were embraced to discover the flexural quality utilizing two-point load testing technique. Shafts were casted utilizing moved channel segments for acquiring required measurements with least mistakes in measurements. The base plates the molds are in with such measurements in order to keep spillage of the materials from the shape.

3.8 Casting

All the moulds were fitted firmly, and the inward dividers of molds were covered with oil to forestall attachment of the solid. First all the necessary amounts of materials fly-debris,

Cement, fine and coarse total were clumped. Prior to going for blending, required amount of Sodium silicate arrangement was taken at that point determined according to blend plan and weighed precisely. In the solid blender first coarse total and fine total were poured and blended completely for quite a while then the folio fly-debris or concrete, were added to the past blend and turned the machine for quite a while with the goal that the cover and totals were blended consistently. At that point the activator Sodium silicate arrangement was poured in to the blend and turned the machine to get uniform blend. Each layer was altogether compacted by a packing bar by giving 25 blows without delivering any isolation or over the top laitance. At long last, the form was compacted with the needle vibrator for around 10 sec. after compaction the top surface was leveled with a trowel and examples were kept on level surface.

3.9 Curing

Portland Cement Concrete PCC

The test specimens were put away at room temperature on the site at a spot liberated from vibrations, under soggy tangling and sacks for 24 hours from the time water added to dry fixings. In the wake of remoulding at 24 hours, examples are quickly drenched in clean water and kept there until before testing. The water utilized for relieving was keeping up at room temperature. Examples were not permitted to dry until testing time

Geopolymer Cement Concrete GPC

The relieving for the fly-debris based geo polymer examples is conveyed by legitimately putting them under daylight. It very well may be done at both encompassing (25oC) and at raised temperatures (40-80oC) .

4.0 Testing of Specimen

Mechanical Tests

Primary tests go under the mechanical tests are compressive test for 3D shapes and three-point stacking for flexural quality assurance on crystal examples. Pillars were tried to comprehend the conduct

4.1 Compressive Strength

The 150 x 150 mm solid blocks are being tried under all inclusive pressure testing machine 2000KN. Top surface of the bearing plate was made clean with no undulations because of broken material before testing. The example was place in the machine in such a way the deliberate compressive quality of the example was determined by isolating the greatest burden applied to the example during the test by the cross-sectional Area, determined from the mean elements of the segment and was communicated to the closest N per mm2. The testing method was done according to arrangements of IS 516-1959

Fig.1Compression testing on Cube

4.2Flexural Strength

For crystals, the flexural quality of geo polymer concrete was resolved utilizing crystal examples by exposing them to two focuses twisting in Universal Testing Machine having a limit of 1000kN.Specimens were set in the machine in such a way, that the heap will be applied to the highest surface as cast in the shape along two lines dispersed at 13.3 cm separated. The hub of the example was made precisely adjusted to the hub of stacking machine. The heap was applied at pace of 180 kg/min with no stun and expanded ceaselessly until the example fizzled .The purpose of split because of disappointment load was estimated in the ductile zone of the crystal for ascertaining the modulus of burst. This test was directed considering suggestions from IS 516-1959.

Fig.2 Two point loading test on concrete prism

Calculating the modulus of rupture value:

The modulus of burst esteem is determined dependent on the area of the watched break. On the off chance that the break starts in the pressure surface inside the center third of the range (between the stacking focuses), figure the flexural quality as:

F = Pl/(bd^2)

Where b = estimated width of the example (mm)

d = estimated profundity of the example at the purpose of disappointment mm

l = length of range on which the example was bolstered

P = Maximum applied Load applied to the example up to disappointment (N)

On the off chance that the break starts in the strain surface outside of the center third of the range length by not in excess of 5 percent of the range length, ascertain the flexural quality as:

F = 3Pa/(bd^2)

a = the normal separation between the line of break and the closest help estimated on the pressure surface of the pillar (mm)

4.3 Flexural test on Beam

Beam of 100 x 200 x 1800 mm was utilized for testing under Dynamic stacking machine. A stacking pace of 1.5 kN/min was received while testing. These bar examples utilized don't require any end tabs. The pillar was stacked by two burdens set evenly between the backings. Right now are four significant focuses (two end underpins with two stacking focuses) along the range of the bar. In this manner, it gives four-point bowing. Subsequently, this strategy is called four-point twisting flexural test on pillar.

Fig.3 Four point bending test on reinforced beam

From the shear power and bowing minute graphs perception there is a pressure fixation at the purpose of stacking. Be that as it may, for four focuses twisting there is uniform bowing minute and both shear constrain and bury laminar shear pressure are zero between the stacking focuses. In this way, it prompts the unadulterated bowing stacking. Such a condition of pressure is alluring in testing. Thus it is wanted to three focuses bowing flexural test strategy. For isotropic material the typical pressure differs straightly over the thickness. The most extreme worry in pressure is on one side and an equivalent greatest in strain on opposite side of the thickness and goes through zero at the mid-plane.

The normal stress and shear force variation through the thickness is shown in Fig. 5.4

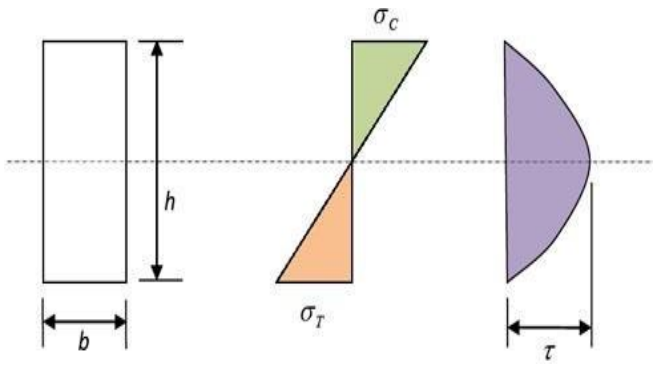

Fig. 4 Bending and shearing stresses in the thickness direction

The flexural reaction of the pillar in three-or four-point twisting test is acquired by recording the heap applied and the subsequent strain. The subsequent strains are estimated utilizing the strain gages reinforced on the pillar in the gage length.. It is obvious from the circulation of the shear power and bowing minute that the condition of worry in examples exposed to three and four-point twisting tests are to some degree extraordinary. Accordingly, it might prompt contrasts in the outcomes.

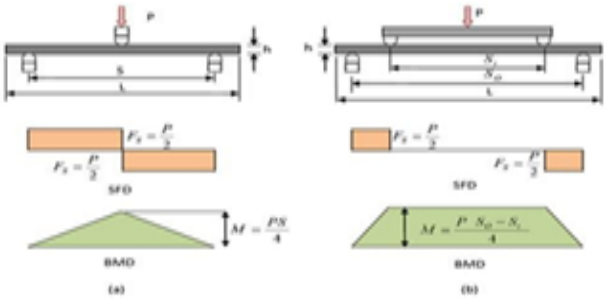

Fig..5 Four point Bending test on Reinforced Beam

IV. RESULTS AND DISCUSSION

Properties of Fresh Concrete*:*

Consistency: The standard consistency of fly debris 61% The typical consistency for fly debris with sodium silicate of (Ms) 1.99 is generally higher than OPC. This might be because of the clingy idea of sodium silicate. As the water rate is low in the sodium silicate, it devours more answer for the particles hydration and in this way hydration process takes additional time. For the most part, for the concrete developments, the necessary beginning setting time is 30 to 45 minutes and the last setting time is 10 hours however the Initial and last setting time for GPC are 19 hours and 45 hours individually

Workability (Slump): The slump of fly ash-based GPC at ideal measurement is 135 mm, and droop of OPC is 123 mm.Generally, the usefulness of Geo-polymer is higher than that of OPC concrete. Geo-polymer can conservative well on a vibrating table in any event, for generally low droop esteem. For the most part when cement accomplishes droop estimation of 90mm and over, it is viewed as an exceptionally functional cement. The droop of fly debris based GPC is 135 mm, and droop of OPC is 123 mm.

5.1Compressive Strength of Cubes.

Table .1 Comparison of 7 Days Compressive Strength

	7 days compressive strength (MPa)			
Material	Sample 1	Sample 2	Sample 3	Average
PCC	29.40	32.42	25.60	29.14
GPC	6.03	5.78	5.95	5.98

Table .2 Comparison of 14 Days Compressive Strength

	14days compressive strength (MPa)			
Material	Sample 1	Sample 2	Sample 3	Average
PCC	29.87	33.40	27.73	30.33
GPC	8.57	8.40	9.24	8.74

Table .3 Comparison of 28 Days Compressive Strength

	28days compressive strength (MPa)			
Material	Sample 1	Sample 2	Sample 3	Average
PCC	44.89	34.84	39.80	39.84
GPC	11.09	10.75	10.42	10.75

Comparison of Stiffness of beam:

Strengthened bar under four point twisting test demonstrating more solidness if there should arise an occurrence of both pre-breaking stage and post splitting stage for PCC pillar contrasted with GPC shaft Reinforcing steel didn't include any impact in expanding the firmness, however it just upgraded the pliability of the bar. It is seen that pre-splitting solidness is more than the post breaking firmness in both Fly-debris based GPC and PCC. Firmness subsequent to breaking is decreased in the two cases as solidness is contributed by just the pressure zone of strengthened bar area. This firmness information was upheld by the Young's modulus acquired from the tests on blocks

Comparison of peak load obtained for beam stiffness test:

Fig. Table.4 Comparison of peak load between GPC and PCC

Sl No	Material	Peak load KN
1	GPC	28.54
2	PCC	33.50

Fig 6. GPC Beam under Four-point load testing

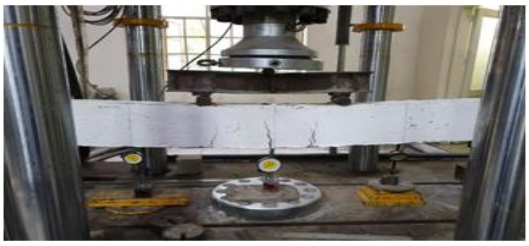

Fig 7. PCC Beam under Four-point load testing

VI. CONCLUSION

Based on the experimental work the following conclusions are drawn In order to create fly debris based Geo-polymer concrete under surrounding restoring condition, enactment of fly debris with sodium silicate arrangement (Silica modulus 1.99) is one of a potential arrangement because of its few focal points. The expenses and dangers included can be diminished by utilizing standard Sodium silicate single arrangement as activator as opposed to utilizing the mix of Na OH and Na2S I O3. Functionality and Strength parts of Geopolymer concrete relieved at encompassing temperature and PCC with water restoring were concentrated by leading an exploratory work Less quality of fly debris based geopolymer concrete was acquired contrasted with PCC. This might be because of restoring under surrounding condition with no warmth relieving framework. Warmth relieving is required if there should arise an occurrence of GPC to accomplish high quality with fly debris alone as a cover To grow high quality geo-polymer concrete under open air relieving condition, mix of fly debris with GGBS is one of a potential arrangement Flexural qualities results were additionally seen as acceptable at encompassing relieved, yet they are seen to be less contrasted with that of PCC. All out supplanting of concrete with Fly debris in geopolymer concrete altogether expands the setting time and aides in achieving high quality with heat restoring. The pace of increase of compressive quality of geopolymer concrete was delayed at an early time of fly-debris based GPC for 7 days when contrasted with 14 and 28 days while it is turn around on account of PCC.

The disappointment watched for GPC bars are seen as at low loads contrasted with that of PCC. From the four-point bowing test on fortified bar it is discovered that both pre-splitting firmness and post breaking solidness as high if there should be an occurrence of customary cement contrasted with that of Fly-debris based GPC.

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