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Adoption of Recycled HDPE Plastic Granules and waste Crushed Glass as a Partial Substitute of fine Sand in Concrete

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Abstract:*There are three issues in India as per the environmental concern. First, the waste plastic disposal solution; second, the over-digging of river sand has led to a restriction on its excavation and third, the disposal of waste broken glass in landfills. Targeting the three issues the waste plastic rarely reused in India and the waste plastic and waste broken glass are non-biodegradable or they diminish at acutely low rate means they endure in the earth environment for a very long-term materials. To solve these issues, introducing the process of adding HDPE plastic granules and crushed waste glass used as a fine aggregate replacement in concrete. In this experiment to increase mechanical properties of concrete (M30 grade) having High-density polyethylene (HDPE) granules used as a partial replacement for fine aggregate (0%, 5%, 10%, 15% & 20%). The characteristics of concrete consisting HDPE plastic granules and crushed waste glass as river sand were studied separately in this investigation. Plastic containing concrete shown decreasing in strength and glass containing concrete shown increasing in strength as increasing in percentage of the materials. After that finding the optimum mix of crushed glass used based on strength of the concrete. Then the last mix proportion contains both plastic and glass (S80G15P5, S75G15P10, S70G15P15 & S65G15P20) shown the better results than the only plastic replaced as a fine aggregate in concrete results.*

Keywords: *HDPE plastic granules, crushed glass, workability, slump, compressive strength, split tensile strength, flexural strength, optimum mix*

I. INTRODUCTION:

Mass extraction of river sand, dredging has been the main issue in India from many years and it's mainly taken by the construction need. As a high court ruled in 2011 has essentially eradicated sand extraction [1]. This result shows by replacing 15% waste glass and 20% HDPE plastic granules it is an acceptable proportion that has implied to save up to 35% of sand every year [2]. Glass is a standout amongst the most prevalent stockpiling and packing items utilized today. It is likewise, one of the most straightforward items to reuse or recycle, preserving both raw materials and landfill space. Glass is an unavoidable component of the Indian economy, where it represents in excess of approximately 20 million metric tonnes of end users products each year yet there is no appropriate administration of waste glass made by consumers.

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The total glass made in India just 45% is reused which demonstrates that there is a requirement for appropriate acquirement and management of waste broken glass. [3].

As per 2011-2012 data of ICPCB [18] noted that almost 15350 tons of waste plastic are discarded per day in India [4]. As everyone knows the plastic (polyethylene) is non-biodegradable means in landfills it breaks downs very slowly and for long term. Then the HDPE plastic recycled as granules and make it used in the construction field as fine aggregate replacement. A solution for these three problems is to adopt by swapping some amount of fine aggregate in concrete mixes with waste HDPE plastic is recycled as HDPE granules and waste broken glass, otherwise debris as waste content in landfills. By this process, it will not only promote the utilization of unused waste material but also provide substitute origin for fine material in the position of river sand in inventive concrete mix.

II. WASTE MATERIALS AS A REPLACEMENT FOR RIVER SAND

Ismail Zainab Z. and Al-Hashmi A. [5] presented that the intensify performance of discarded plastic waste up to 20% in concrete mix as fine aggregate are shown decreasing in slump, compressive strength, split tensile strength and flexural strength by rising the proportion of discarded plastic waste in the concrete at any curing period. E. Rahamani et al. [6] studied on hardened properties of concrete consists waste PET particles. For constant water to cement ratio, the workability of concrete was decreased as the amount of PET particles increasing in the concrete mix. Coming to the compressive strength and flexural strength of concrete with PET particles shown different behaviour. The compressive strength increased by 5% replaced PET particles by 8.86% than the conventional concrete. Further increase of PET particles, compressive strength, split tensile strength and flexural strength decreases. The presences of PET particles would have a more voids in structure which causes a decrement in USPV (ultrasonic pulse velocity). PET particles 10% in concrete shows similar compressive strength as without PET particles in concrete. S. C. Kou et al. [7] studied on hardened properties of light-weight concrete made with plastic PVC (Poly Vinyl Chloride) granules made from scrap PVC (Poly Vinyl Chloride) pipes. River fine sand was partially substitute by plastic PVC (Poly Vinyl Chloride) granules in a percentage 0%, 15%, 5%, 45% & 20% by its volume.

Effect of incorporating the PVC granules as lightweight aggregate in concrete, the densities and workability of lightweight concrete were decreased. The compressive strength and split tensile strength were decreased. The ductility of PVC (Poly Vinyl Chloride) concrete was enhanced. And he said that PVC granules are utilized as aggregate to restore the sand for making lightweight concrete the optimum usage of PVC granules are up to 15%. Malek Batayneh et al [8] Studied on three different mixes as a fine sand replacement with the waste materials waste glass, waste plastic and demolished concrete. The results are shown by replacing the waste broken glass as fine sand in a concrete increase in a slump value and compressive strength and split tensile by rising the proportion of crushed waste glass. The results are shown by replacing the waste plastic and demolished concrete aggregate in concrete decreases in a slump and compressive strength and split tensile by rising the percentage of discarded plastic and recycled aggregate. Ismail Zainab Z. and Al-Hashmi A [9] stated that the performance of crushed waste glass in the concrete mix as fine aggregate shown the increase in compressive strength and flexural strength by increasing the proportion of crushed glass in concrete.

III. MATERIAL SPECIFICATIONS

The materials used in mix design cement, fine aggregate and coarse aggregate should satisfy the code IS 10262-2009 [35]. And fine aggregates are river sand, HDPE plastic granules and crushed glass.

A. Cement

Ordinary Portland Cement (OPC) of grade – 53 conforming to Indian standards IS: 12269-1987 [11] is used in this study. With specific gravity 3.15, confirming to IS 4031-1996 [12] the other physical properties are tabulated below. (Table 3.1)

Table 1: physical properties of cement

S.NO	Description	observations
1	Specific gravity of cement	3.145
2	Fineness of cement	8
3	Standard consistency of cement	33%
4	Initial setting time of cement	90 minutes
5	Final setting time of cement	350 minutes
6	Compressive strength of cement(Mpa)	
	28days	55.3

B. Aggregate: {IS 2386:1963 (part-3) [13]}

Fine aggregate utilized in this experimental process was river sand of zone2 of specific gravity 2.55 confirming IS 383-1970 [10]. The physical properties of fine aggregate are tabulated below. (Table 3.2)
Coarse aggregate used in this was angular of size 12.5mm confirming to IS 383-1970 [10]. The physical properties of Coarse aggregate are tabulated below.

Table 2: physical properties of aggregates

S. N O	Description	Fine aggregate	Coarse Aggregate
1	Specific gravity of fine aggregate	2.72	2.92
2	Water absorption of fine aggregate	0.776	0.25
3	Bulk density of compacted aggregates	1.56	1.58
4	Bulk density of loosely packed aggregates	1.42	1.46
5	Fineness modulus of Fine aggregates	3.15	7.36

C. HDPE plastic granules

The waste HDPE plastic is gathered and it is recycled into the granules. In this paper, the HDPE plastic granules are collected from Hyderabad, Jeedimetla [17], plastic factory.

Fig 1: HDPE plastic granules

Table 3: physical properties of HDPE plastic granules and Crushed glass

S.No	Description	HDPE plastic granules	Crushed glass
1.	Density (g/cm^3)	.94	1.62
2.	Specific gravity	.89	2.52
3.	Mean size of a particle	2mm-3mm	1mm-2mm
4.	Colour	Black	White

D. Crushed glass

Waste glass is collected from the local glass emporiums (Visakhapatnam) and made into pieces first and then crushed as fine as sand.

Fig 2: Waste glass

Fig 3: After crushing the glass

IV. CONCRETE MIX DESIGN: (IS 10262-2009 [14])

Concrete is a composite blend which contains of Cement, fine sand and coarse aggregate. Concrete mix design is the methodology for finding the correct amounts of these materials to accomplish the ideal quality. Exact concrete mix makes concrete construction practical and economical. The mix proportions are tabulated below.

Mix proportions:

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Table 5: Mix proportion of conventional concrete

Grade designation	Cement (kg/m^3)	F.A (kg/m^3)	C.A (kg/m^3)	W/c ratio
M30	360	750.41	1309.55	.45

V. INVESTIGATIONS MADE

A. Mixing proportion

Four varieties of concrete mixing proportions were made in this study. The first concrete mix is conventional concrete mix, which consisting of cement, fine sand, gravel (**1: 2.08: 3.64**) and water/cement is 0.45, resulted in water (162 lit). Second concrete mixes were made of HDPE plastic granules aggregate of S100, S95P5, S90P10, S85P15 & S80P20 as a partial replacement for sand, third concrete mixes were made of crushed glass aggregate of S100, S95G5, S90G10, S85G15 & S80G20 as a partial substitute of river sand and with the same quantity of cement and coarse aggregate and water/cement as in the plain mixes.

Table 6: Mix proportion of concrete with HDPE plastic

Mix mode	Cement content (kg/m^3)	Coarse aggregate (kg/m^3)	Fine aggregate		Water (lit)
			Sand (kg/m^3)	HDPE plastic granules (kg/m^3)	
S95P5	360	1309.55	712.88	37.53	162
S90P10	360	1309.55	675.35	75.06	162
S85P15	360	1309.55	637.82	112.59	162
S80P20	360	1309.55	600.29	150.12	162

Table 7: Mix proportion of concrete with crushed glass

Mix mode	Cement content (kg/m^3)	Coarse aggregate (kg/m^3)	Fine aggregate		Water (lit)
			Sand (kg/m^3)	Crushed glass (kg/m^3)	
S95G5	360	1309.55	712.88	37.53	162
S90G10	360	1309.55	675.35	75.06	162
S85G15	360	1309.55	637.82	112.59	162
S80G20	360	1309.55	600.29	150.12	162

Table 8: Mix proportion of optimum mixes

Mix mode	Cement content (kg/m^3)	Coarse aggregate (kg/m^3)	Fine aggregate			Water (lit)
			Sand (kg/m^3)	Crushed glass (kg/m^3)	HDPE plastic (kg/m^3)	
S80G15P5	360	1309.55	605.92	112.59	31.89	162
S75G15P10	360	1309.55	574.08	112.59	63.78	162
S70G15P15	360	1309.55	542.15	112.59	95.67	162
S65G15P20	360	1309.55	510.25	112.59	127.56	162

Finding the most favorable proportion of crushed glass from third mix results and fourth mixes were made of optimum percentage crushed glass aggregate and HDPE plastic granule aggregate S100, S80G15P5, S75G15P10, S70G15P15 & S65G15P20 as a partial replacement for sand with same amounts of cement, gravel and water/cement as in the conventional mix.

Fig 4: a) only crushed glass b) both crushed glass and plastic granules

B. Preparation of specimens.

1. *Casting, compaction and curing*: The casting, compaction and curing are done accordingly to IS 516-1959 [16].
2. *Workability tests:* Slump cone test and compaction factor are done accordingly to IS 1199-1959 [15].
3. *Split tensile strength:* cylinders [150mm (dia) × 300mm (height)] are casted accordingly to IS 516-1959.
4. *Compression strength:* concrete cubes (100mm×100mm×100mm) were prepared according to IS 516-1959.
5. *Flexural strength:* prisms are prepared as per IS 516 – 1959.

III. RESULTS AND DISCUSSION

A. Slump tests:

i. From fig 6, slump tests results of concrete with HDPE plastic shows in fig 3, the slump value decreases by increasing the percentage of HDPE plastic granules of S95P5, S90P10, S85P15 & S80P20 replacement as fine aggregate decreasing in percentage 13.37%, 20%, 46.67% and 48.34% respectively.

Fig 5: Measuring slump value

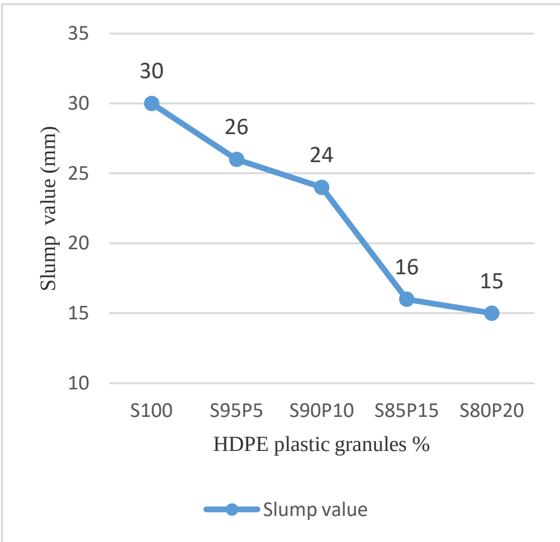

Fig 6: Slump value of concrete with HDPE plastic granules

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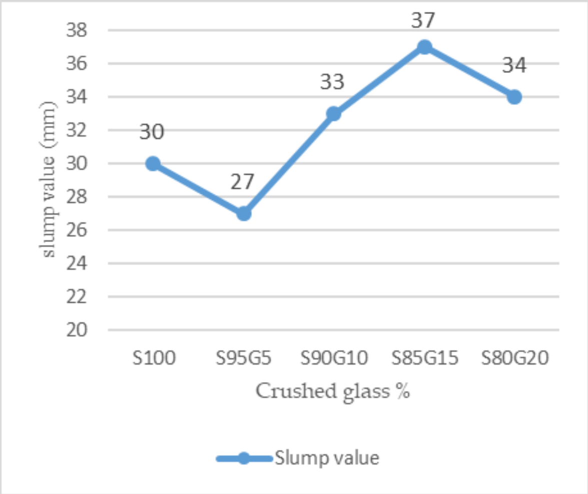

Fig 7: Slump value of concrete with Crushed glass

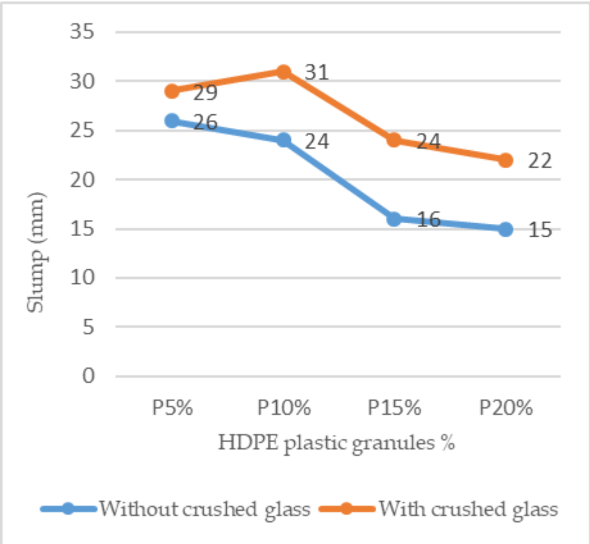

Fig 8: Comparison graph for a slump of concrete using plastic with and without Crushed glass

ii. From fig 7, the slump value of the concrete with crushed glass is increased from 10% to 20% of replacement. For S95G5 replacement the slump value is decreased of 10% slump value to the conventional concrete slump and increased for S90G10, S85G15 & S80G20 are 10%, 23.3% and 13.3% respectively slump value to the conventional concrete slump value.

iii. From the fig 8, shows the comparative results of the slump value of concrete using HDPE plastic granules with and without crushed glass. The variation of HDPE plastic granules by increment of 5% up to 20% (i.e., S80G15P5, S75G15P10, S70G15P15 & S65G15P20). The slump was increased by using the crushed glass in the concrete mix. The amount of percentage increase 11.53%, 29.167%, 50% and 46.67% for replacement of HDPE plastic granules respectively.

B. Compressive strength

i. From fig 10, the compressive strength of concrete is observed the amount of HDPE plastic content increases S95P5, S90P10, S85P15 & S80P20 the strength is decreasing for 7 days 5.59%, 19.58%, 21.3% and 25.87% respectively and for 28 days 7.1%, 9.94%, 16.27% and 19.56% respectively compared to the conventional concrete.

Fig 9: compressive strength specimen

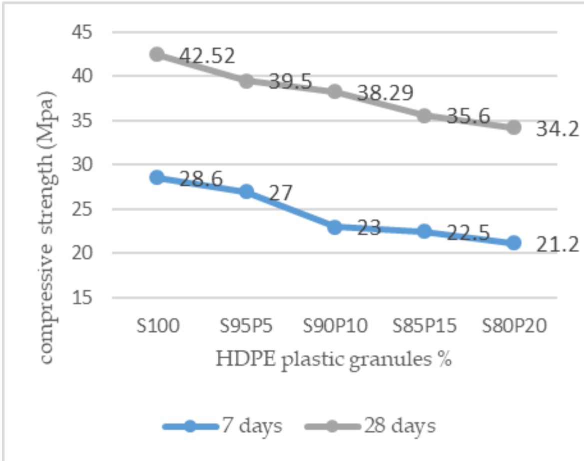

Fig 10: Compressive strength of concrete with HDPE plastic granules

Fig 11: Compressive strength of concrete with Crushed glass

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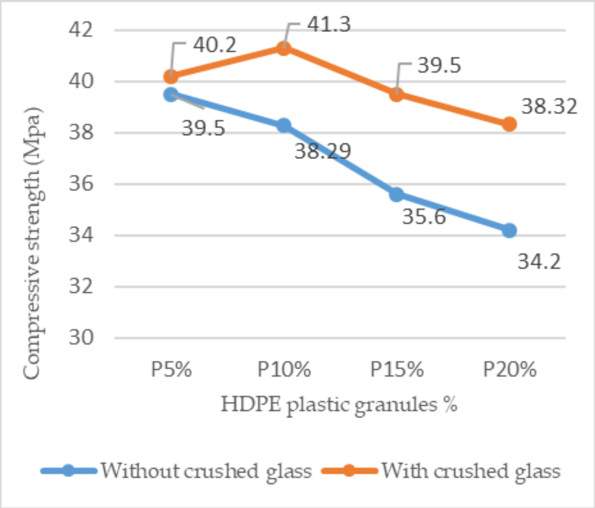

Fig 12: Comparison graph for compressive strength of concrete using plastic with and without crushed glass (28 days)

ii. From fig 11, the compressive strength of concrete with increases crushed glass content S95G5, S90G10 & S85G15 for 7 days decreased with 3.6%, 3.02%, and 2.14% respectively. Increased for S80G20 for 7 days with 1.75% and for 28 days increased with .35%, 1.71%, 8.13% and 1.66% respectively to the crushed replacement.

iii. From the fig 12, shows the comparative results of 28 days compressive strength of concrete using HDPE plastic granules with and without crushed glass. The variation of HDPE plastic granules by increment of 5% up to 20% (i.e., S80G15P5, S75G15P10, S70G15P15 & S65G15P20). The compressive strength was increased by using the crushed glass in the concrete mix. The amount of percentage increase 1.77%, 7.8%, 10.95% and 12.04% for replacement of HDPE plastic granules respectively.

C. Split tensile strength

i. From fig 14, Split tensile strength is observed that for S95P5, S90P10, S85P15 & S80P20 of crushed glass replacement are increased for 7 days with 5.57%, 5.26% and 13.68%, decreased with 3.82% respectively and for 28 days decreased for S95P5 and S80P20 replacement with 19.04% and 6.38% respectively and increased for S90P10 and S85P15 replacement with 8% and 4% respectively.

Fig 13: Split tensile specimen

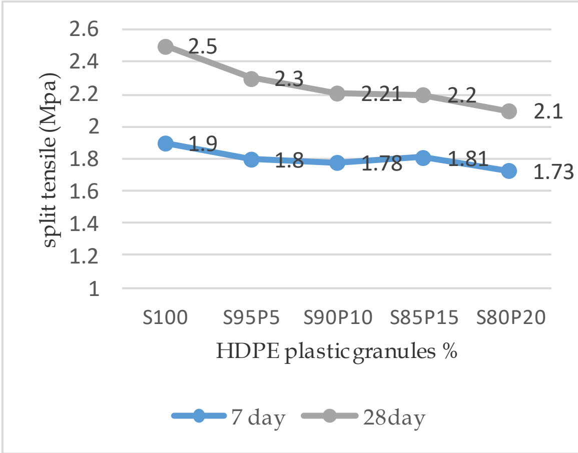

Fig 14: Split tensile strength of concrete with HDPE plastic granules

ii. From fig 15, Split tensile strength is observed that for S95P5, S90G10, S85G15 & S80G20 of HDPE plastic granules and optimum crushed glass replacement are decreased for 7 days with an amount of 0.53%, 3.69%, 5.37% and 6.32% and for 28 days with an amount of 12%, 7.2%, 8% and 7.6% respectively.

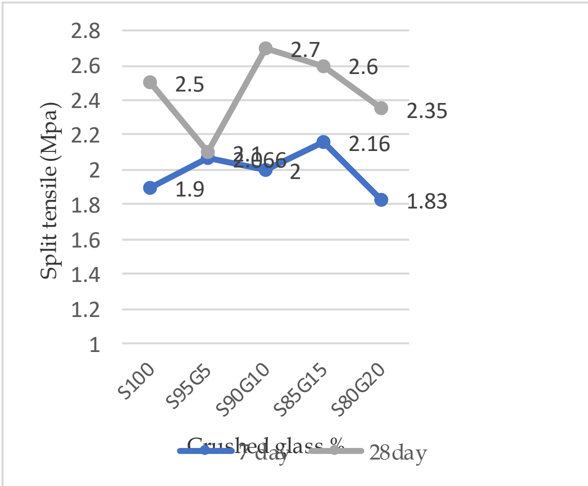

Fig 15: Split tensile strength of concrete with Crushed glass

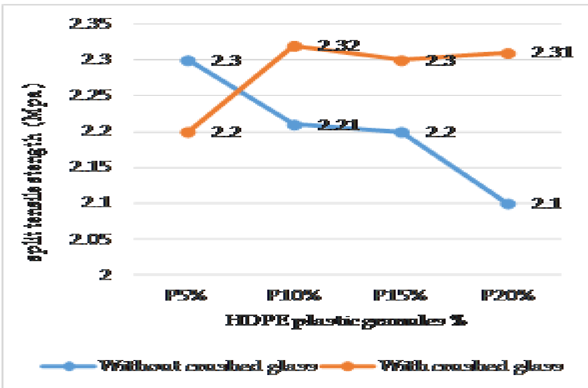

Fig 16: Comparison graph for split tensile strength of concrete using plastic with and without crushed glass (28 days)

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iii. From the fig 16, shows the comparative results of 28 days split tensile strength of concrete using HDPE plastic granules with and without crushed glass. The variation of HDPE plastic granules by increment of 5% up to 20% (i.e., S80G15P5, S75G15P10, S70G15P15 & S65G15P20). The split tensile strength was increased by using the crushed glass in the concrete mix. The amount of percentage increase by 4.97%, 4.54% and 10% for 10%, 15% & 20%replacement of HDPE plastic granules respectively. For 5% replacement, it was decreased by amount of 4.35%.

D. Flexural strength

i. From fig 17, Flexural strength is observed that for S95P5, S90P10, S85P15 & S80P20 of plastic granules replacement are decreased by for 7 days are 37.85%, 40.67%, 45.76% and 48.3%, for 28 days are 33.5%, 39.9%, 42.75% and 42.9% respectively.

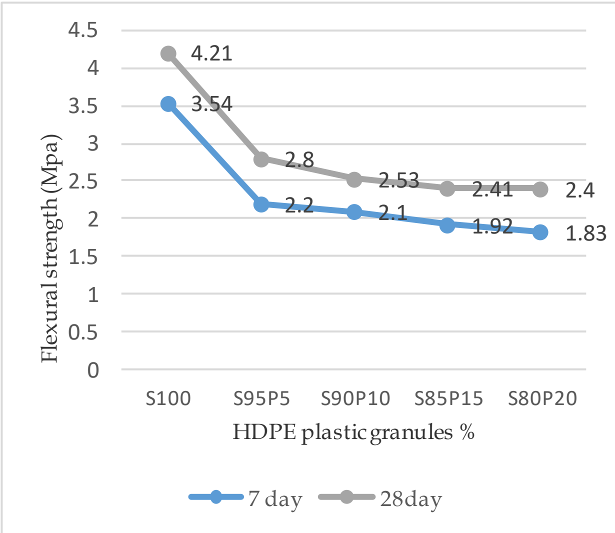

Fig 17: Flexural strength of concrete with HDPE plastic granules

ii. From fig 18, Flexural strength is observed that for S95P5, S90G10, S85G15 & S80G20 of crushed glass replacement are increased for 7 days with 3.1%, 2.23% and 0%, decreased with 9.59% respectively and for 28 days decreased for 10% replacement with 2.1% and increased for 5%, 15% & 20%replacement with 5.2, 7.1% and 9.45% respectively.

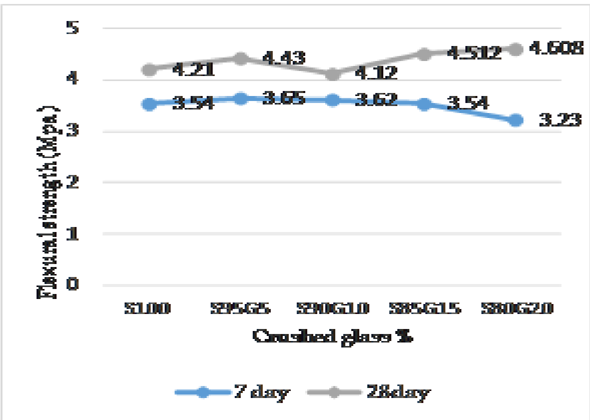

Fig 18: Flexural strength of concrete with Crushed glass

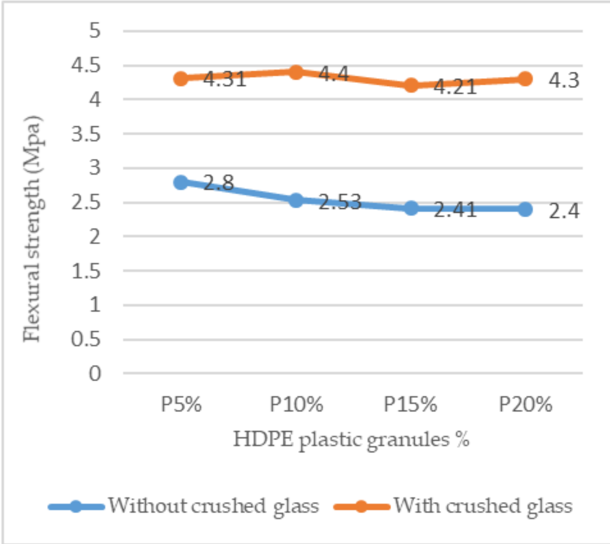

Fig 19: Comparison graph for flexural strength of concrete using plastic with and without crushed glass (28 days)

Fig 20: Flexural strength in Universal testing machine

iii. From the fig 19, shows the comparative results of 28 days flexural strength of concrete using HDPE plastic granules with and without crushed glass. The variation of HDPE plastic granules by increment of 5% up to 20% (i.e., S80G15P5, S75G15P10, S70G15P15 & S65G15P20). The flexural strength was increased by using the crushed glass in the concrete mix.

The amount of percentage increase 53.92%, 73.91%, 74.68% and 79.16% for replacement of HDPE plastic granules respectively.

IV. Conclusion

This paper presents the fresh and mechanical properties of concrete incorporated with HDPE plastic granules and crushed glass. Mixes of M30 were prepared by replacing the fine aggregate with 5%, 10%, 15% & 20% of plastic and glass in respective mixes. Based on the study, the following conclusions are stated below:

- The workability of concrete decreased consecutively by increasing the percentage of HDPE plastic granules in concrete.
- Out of the four mixes (S95P5, S90P10, S85P15 and S80P20) S95P5 and S90P10 performed better hardened properties.

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- With an increasing percentage of crushed glass by an increment of 5% in each mix, workability and strength were increased by 23.33% and 8.14% respectively for S85G15 mix when compared to conventional concrete.
- Workability and hardened properties of concrete mixes were performed better up to S65G15P20.
- Strength of all four mixes up to S65G15P20 comparatively more than the only HDPE plastic granules replaced in concrete.
- It is observed that by replacement of 15% of waste glass and 20% of HDPE plastic granules are identified and concluded as an acceptable proportion by saving 35% of sand.

REFERENCES

1. **Zeenews, sand mining ban in Maharashtra threatens mega projects [online].** **http://zeenews.india.com/news/maharashtra/sand-mining-ban-in-maharashtra-threatens-mega-projects 659907.html**
2. **https://weather.com/en-IN/india/news/news/2018-10-26-illegal-sand-mining-indias-biggest-environmental-challenge (sand extraction per year.)**
3. **https://www.cpcb.nic.in/displaypdf.php?id=cGxhc3RpY3dhc3RlL21hbmFnZW1lbnRfcGxhc3RpY3dhc3RlLnBkZg== (overview of plastic waste management)**
4. Impact of recycling glass in a glass industry: A project management study.
5. Zainab Z. Ismail, Enas A. AL-Hashmi, "Use of waste plastic in concrete mixture as aggregate replacement", Elsevier waste management, vol-28 (2008), pp. 2041-2047, Oct. 2007.
6. E. Rahmani, M. Dehestani, M.H.A. Beygi, H. Allahyari, I.M. Nikbin,"On the mechanical properties of concrete containing waste PET particles", Elsevier construction and building materials, vol-47 (2013), 1302-1308, July 2013.
7. S.C Kou, G. Lee, C.S Poon, W.L. Lai, "properties of lightweight aggregate concrete prepared with PVC granules derived from scraped PVC pipes", Elsevier waste management, vol-29 (2009), pp. 621-628, August 2008.
8. Malek Batayneh, Iqbal Marie, Ibrahim Asi, "Use of selected waste materials in concrete mixes", Elsevier waste management, vol-27 (2007), pp. 1870-1876, November 2006.
9. Zainab Z. Ismail, Enas A. AL-Hashmi**,** "recycling of waste glass as a partial replacement for fine aggregate in concrete", Elsevier waste management, vol-29 (2009), pp. 655-659, Oct. 2008.
10. IS 383-1970, specification for coarse and fine aggregate from natural source for concrete.
11. IS 12269-1987, specification for OPC 53 grade cement.
12. IS 4031-1988, test on cement.
13. IS 2386-1963 (part-3), tests for aggregate of concrete.
14. IS 10262-2009, for mix design calculation.
15. IS 1199-1959, workability tests.
16. IS 516-1959, casting, compaction and curing, tests on hardened concrete.
17. Location of plastic granules collected. https://www.google.com/maps/dir//17.515502,78.448838/@17.5105901,78.4356749,14.5z
18. ICPCB - Indian central pollution control board

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