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Enhancement of Self-Compressing Concrete Grade M35's Compressible Power by the Use of Quarry Powder

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A B S T R A C T

The study's objective was to ascertain the self- compacting concrete's flowability and compression strength. Quarry powder has been used in proportions of 10%, 20%, 30%, and 40% to substitute the sand, and 0.9% super plasticizer has been added. The Building Sandip Foundation's Shri Ram Polytechnic concrete laboratory served as the site for the experiments. To work out the flowability of self- consolidation concrete, cone flow and J - ring trials was performed, and compression tests were performed on days seven and twenty-eight of the curing period. One study finding indicates that adding quarry dust has improved flowability and strength at compression. It has been determined that adding up to 30% quarry dust enhances the self-consolidating concrete's flowability, whereas adding more quarry powder reduces it. Furthermore, the compressible strength of the self-consolidating concrete altered with quarry dust has a tendency of increasing up to 30% when sand is substituted with quarry dust, after which it decreases.

Keywords***:*** Quarry powder; Self - Consolidating Concrete; Flowability; Compression force.

1. INTRODUCTION

The majority of products that are made from cement have been available on planet Earth throughout mankind's history. For building infrastructure development concrete is widely and very commonly used composite materials and likely to used in the future because it is very richly accessible, very reasonable in cost, easily transported, placeable, compactable, outstanding compressive strength, longevity, sustainability, and adaptability to a variety of environments [1-2]. The need for concrete has grown in the context of contemporary infrastructure construction. Ordinary concrete requires professional operators to manage in complicated concrete projects since improperly compressed concrete results in non-durable concrete buildings. Okamura developed self-compressing concrete (SCC) in 1986 after researching the longevity and compression of concrete at Tokyo University [3][4]. Self- compressing concrete is among the best innovations in the building sector [5]. Self-compaction is the process by which freshly mixed concrete streams under gravity over an extended period of time without separation or the use of vibrating devices to achieve proper compaction. More widespread applications of SCC include labor savings and the reduction of vibration-induced compaction noise [6]. The key role of the advancement of self compressing concrete is to deliver compaction without vibration, more endurable, long-lasting concrete that is fluently shapeable into any form. It was vital to create concrete that could support its own weight and didn't require outside force to shake or compacted during the shaping process since regular concrete is difficult to consolidate in complicated structures [2].

Quarry powder, a by-product generated during the pressing of rocks, is a fine substantial often regarded as waste. Its production contributes to air pollution, making its disposal a significant environmental challenge. However, incorporating quarry dust into construction practices can mitigate disposal issues, reduce construction costs, and alleviate air pollution concerns. In some developing nations, quarry dust is being utilized as a sustainable substitute for fine aggregate in building materials, offering an eco-friendly alternative to natural resources [7]. Quarry dust has found diverse applications in the construction industry, including its use in structural resources, road construction, aggregates, bricks, and tiles. Incorporating quarry powder into constructional resources, particularly as a substitute for fine aggregate, has shown potential to enhance compressive strength. This approach has recently gained attention in the field of construction materials. The growing interest in utilizing quarry powder as a fine-grained material substitute, especially in self - compressing concrete, has highlighted the need for further research. This study, conducted within a limited timeframe, aims to address this gap and achieve key objectives related to sand replacement with quarry dust.

- To evaluate the flowability of traditional concrete, self- compressing concrete, and self- consolidating concrete with Powder from quarries as a fine-grained material substitution (Level 35) through performing the cone trial, cone flow test, and J - ring test.
- To assess the compression force of traditional concrete, self- compressing concrete, and self- consolidating concrete incorporating powder from quarries as a fine-grained material substitution (Level 35).

- To find out the optimal proportion of powder from quarries in self- compressing concrete (Level 35) for enhanced performance.

2. LITERATURE REVIEW

Self- Compressing Concrete (SCC) needs an elevated degree of flowability in its fresh state to flow and settle by itself without external compaction. The practice of quarry powder as a partial or complete substitution for fine aggregate has gained responsiveness not only as a solution to environmental pollution but also for its potential to enhance the compressible force of concrete. Recently, the exchange of sand with quarry powder in SCC has become a focal point for researchers, addressing the knowledge gap from earlier limited studies in this area [9]. Research indicates that substituting quarry dust for sand can both improve compression strength and drastically lower the expense of self-contracting concrete [9]. Although quarry dust may be used to produce SCC when it is partially substituted for cement, a larger dose of superplasticizer is required to obtain comparable flow characteristics because of the uneven distribution of quarry dust particles [10]. It is advised to utilize quarry dust in concrete to some extent in areas where fine aggregate is either expensive or unavailable [11]. According to the study, as compared to control concrete, whenever 50% of the fine-grained material is exchanged with quarry powder, the highest compressing force is obtained [12]. As more quarry residue is substituted, SSC becomes less feasible. The chemical makeup of fine-grained stone and the strength properties of quarry residue are comparable. According to experimental data, M20 grade concrete performs better when 40% of the sand is replaced with quarry waste [14]. SCC is often finished using the identical basic ingredients as regular vibrating concrete (NVC), which include cement, fine-grained material, course-grained material and water, and a few additives of chemicals. Using chemical admixtures is crucial to improving flowability and reducing SCC segregation. To achieve great flowability with minimal viscosity variations in self-compacting concrete, superplasticizer (SP) is a necessary ingredient. A brief explanation is given of the operation of self- compressing concrete mixed through various raw material groups in several investigations.

2.1 USING NATURAL MINERALS IN CONCRETE THAT COMPACTS ITSELF (SCC)

2.1.A Fly Ash

The outcomes indicate that the age (in days) 28 compression force of self- compressing concrete is 26–48 MPa, with cement replacing the fly ash mixture by 40%, 50%, and 60% [15]. The researchers [16] looked at how a large amount of fly ash affected its penetrability of self- compressing concrete and discovered that the age of SSC had a significant impact on the fly ash content's effect on porosity. High voids are seen in SCCs under 56 days of age, whereas lesser voids are shown in SCCs 90 days of age. Fly ash was used to replace 0-80% of Portland cement [17]. The study discovered that bulk amount of fly ash combined with SCC produces outstanding force and minimal contraction. The best compressible strength was seen after 56 days when 40% of cement was substituted with fly ***Mix proportions***

There were eleven SCC blends made with traditional SCC. Every batch of concrete was M60 standard. Fly ash was used in place of quarry dust in combinations of Fly Ash (FA5, FA10, FA15, and FA20). These mixtures had total dust contents of 550 kg/m3 and comprised 5%, 10%, 15%, and 20% fly ash, respectively. The following mixtures were created using 5%, 10%, and 15% G.G.B.S. in addition to silica dust in place of fine aggregate. All blend permutations had the same level of superplasticizer (10.8 kg/m^3). The quarry dust concentration in the typical Self Consolidating Concrete (SCC) blend was held at 45% by proportion (910 kg/m3) of mortar in tangible and 39% by proportion (588 kg/m3) of tangible, while the moisture-powder proportion was preserved at 0.30, 0.35, and 0.40 by mass with an estimated entrapped air of 2%. List 2 provides information on different percentages.

2.1.B Silica Dust

Silica dust has been substituted for Portland cement in order to examine the impact on SCC performance [18]. According to the research, SCC mixes that contain silica dust have a less pronounced top-bar impact than regular concrete and are nearly completely eradicated at substitution rates of 8.89% to 10.76% (by weight). Studies have shown an elevated setting time.

The outcomes of an equivalent study that examined the fly ash's impacts and silica dust on SCC (fluidity, compression force, and splitting tensile strength) indicate that when silica fume [19] was utilized exclusively as a pozzolanic ingredient instead of fly ash, both the compressible and split tensile strengths increased progressively. In comparison to fly ash blends for the identical water/bond ratio, the power of all mixtures including silica dust was generally observed being on the top side. To increase ductility and lower the overall expense of the SCC, a second comparison research [20] comparing steel fiber and silica fume was carried out. According to the research results, fiber from steel enhances the power-driven qualities of SCC. Furthermore, the silica dust present in the complete amalgam mixture might be able to modify the fiber diffusion and reinforce fiber-related deficiencies. When SCC has a thick calcium silicate-hydrate gel, it may additionally strengthen the fiber's connection with the matrix.

2.1.C Trail of Specimen

The use of adding crushed limestone to self-compacting concrete and its mechanical and physical characteristics were examined by [21].

The findings demonstrated that the mechanical characteristics of SCC have enhanced and that limestone dust produces regular strength. The impact of incorporating limestone dust Portland cement to w/c proportion is used with SCC. of 0.38 by weight was examined in a study [22]. Five, ten, and fifteen percent of the limestone dust was introduced. The study discovered that while compression strength reduced as the amount of limestone dust grew, marsh conical flow, slumping flow, and V funnelling flow period enhanced. In the investigation, fine aggregate was completely substituted with limestone dust, and the findings showed that by partially replacing fine aggregate, limestone dust may enhance SCC [23].

2.1.D Marble Dust

Similar to extra natural waste, marble powder is extremely frequently used as a construction material. Although marble trash is a by-product that may be used extensively in concrete, there aren't many research that demonstrate how adding marble waste to concrete that self-compacts can enhance its qualities.

This study explored the impact of partially substituting the Portland cement (10–40%) with marble crumbs mixed with SCC [24]. The flowability and compression strength have significantly improved, according to the study's findings.

A study that looked at partially replacing fine aggregate with marble powder discovered that while a large percentage of fine aggregate decreased the strength of compression, marble powder increased the mechanical characteristics of SCC [25].

Reactive surface approach was used to study the produced SCC with marble dust addition. By adding the most marble powder possible, an ecologically friendly SCC combination was found using a multi-objective optimal approach. Using cement to water proportions less than 0.55 and a marble particle versus cement proportions up to 0.6, the environmentally friendly SCC was achieved [26].

2.2 ADDITION OF FIBERS IN CONCRETE THAT COMPACTS ITSELF (SCC)

2.2.A Steel Fiber

Fibres are widely recognized for improving the characteristics of concrete, and their impact on self-setting concrete was examined using fibers made of steel. According to a research, regulate SCC and SCC with fibers from steel were compared. In the sulfate atmosphere, steel fibers had no discernible impact on the SCC's longevity [27,28].

2.2. B Polymer

For the purpose of testing the mechanical and microstructural features of self-compressing concrete, scrap tire rubber has been employed in the polymer's inclusion [29]. Utilizing polymer inclusion with SCC leads to improved characteristics. Self-compressing concrete's mechanical qualities are not significantly harmed by the presence of acrylic polymer or micro-SiO_2 [30]. Employing these substances also results in their improvement.

3. CONSTITUENTS AND PROCEDURES

Quarry waste is used to substitute fine aggregate in quantity of 10%, 20%, 30%, and 40%. To accomplish the research's goal, practical tests for compressible strength, Both the slumping test and the J-Ring test succeeded in accordance with Indian and British (BS) standards. A list of the components utilized in the experimental investigation is provided.

3.1 Cement

IS 12269: 2013: Ordinary Portland cement (OPC) has been utilized; Table 1 lists the cement's characteristics.

Table 1. IS 12269: 2013: characteristics of cement

Specific gravity	3.15
Standard consistency (%)	27.75
Initial setting (min.)	30
Final setting (min.)	600
Average compression force (MPa) on 28th Days	53

3.2 Fine Aggregate

Table 2 displays the fine material gradation that was utilized.

Table 2. Fine-grained materials gradation

Sieve Size (mm)	Weight Engaged (g)	% passage
10	0.06	96.85
5	0.19	94.01
2.36	0.87	62.98
1.18	1.49	14.78
600 microns	0.2	8.25

3.3 Course-grained materials

Table 3 displays the grade of the course aggregate utilized in the broken granite rock.

Table 3. Course-grained materials gradation

Sieve Size (mm)	Weight Engaged (g)	% passage
20	0.89	92
14	4.85	38.01
10	0.8	28.85
5	1.5	11.92

3.4 Mix Design

The characteristics of the substances and the quantity of the mixture can have a significant impact on the self-compatible nature. In the current study, the mixture of composition and component quantities were determined using the Su [31] approach.

Table 4. **Mix Design**

NO.	Blend	Cement (Kg/m^3)	Sand (Kg/m^3)	Water (lit.)	Aggregate (Kg/m^3)	QP (Kg/m^3)	SP (Kg/m^3) (0.90 %)
1	Conv.	421	852	211	925	_	_
2	SP	421	852	211	925	_	3.6
3	QP10	421	763	211	925	86	3.6
4	QP20	421	678	211	925	172	3.6
5	QP30	421	597	211	925	252	3.6
6	QP40	421	515	211	925	336	3.6

4. OUTCOME AND DISCUSSION

4.1 Flowability

Filling, passing, and separation resistance are characteristics of self-compaction concrete. Table 5 lists the slump and J - Ring test suggested norms from the “European Federation of National Trade Associations” instead of manufacturers and applicatory of specialty structural materials “(EFNARC)” [32] and “ASTM” [34].

Table 5. Suggested standards

No	Characteristics	Scale
1.	Dia. of Slumping Flow	500-700 mm
2.	J - Ring	0-10 mm

The slumping flow trail, J rings as well as their flow were shown in Table 6. According to the research, adding super plasticizing agents SP to concrete results in slump flow of 543 mm, two different J ring flows: 6.27 mm and 512 mm. These levels fall between the ASTM [34] and EFNARC [32] specifications' suggested limit. Quarry powder is substituted for sand or fine aggregate in the 2nd phase at percentages of 10%, 20%, 30%, and 40%. The slump flow outcomes in 551, 602, 675, and 632 mm, accordingly.

Additionally, J ring flow is 518, 565, 630, and 585 mm, and J ring parameters are 7.59, 7.7, 9.28, and 8.8 mm, accordingly. The results indicate that adding 10–30% quarry residue improves the self-compacting concrete's flowability; additional additions that result in a drop in slump flow indicate less flowability.

The two different J ring flows (mm) measurements in List 6 and the slump flow that was determined fall within ASTM and EFNARC guidelines.

ID	SLUMP FLOW (500 to700) mm	J-Ring (0-10) mm	J-Ring Flow (mm)
S.P.	543	6.27	512
10 %	551	7.59	518
20 %	602	7.7	565
30 %	675	9.28	630
40 %	632	8.8	585

4.2 Compression Force Test

SCC cubes are put through a compression strength test. Determining the self-compacting concrete's compression strength in contrast with control specimens is the research's second goal.

The test was planned for the seventh and twenty-eighth days after the specimens were treated with water. For every group, the compression test was conducted three times, and its average strength at compression was calculated and displayed in Table 7.

The control specimens' average strength of compression on days 7 and 28 were 26.93 and 36.13 MPa, respectively. Based on the findings, adding super plasticizing agents to the concrete increased its compressible strength on days 7 and 28, which were 27.52 and 35.88 MPa, respectively.

The 7-day compressible strength is 23.67, 25.28, 29.25, and 28.30 MPa, respectively, when sand is replaced with quarry waste at 10, 20, 30, and 40%. After 28 days, the compression strengths are 35.29, 36.48, 37.36, and 36.41 MPa, respectively.

According to the results, adding quarry waste to sand in amounts of 10–30% increases its strength at compression, whereas adding more reduces it. The strength at compression of the self-compacting concert is shown in Figure 1 and Table 8 for the comparison of SSC cubes cured for 7 and 28 days.

Accordingly, research has established that the strength at compression of 7 and 28 days falls within the range since previous studies have shown that adding 10–30% quarry waste in place of sand increases the compression strength.

Table 7. Compression Force outcomes of numerous concrete blends

Age (in Days)				
Percentage of Replacement	7 (in days)		28 (in days)	
	Compression Force (MPa)	Mean value (MPa)	Compression Force (MPa)	Mean value (MPa)
Conv.	25.15	26.93	36.85	36.13
	26.15		34.98	
	28.58		37.01	
	27.83		35.68	

SP (0%)	27.95	27.52	37.12	35.88
	28.64		36	
	25.98		34.52	
QP - 10%	23.04	23.67	35.23	35.29
	22.98		34.53	
	24.98		36.12	
QP - 20%	24.75	25.28	35.23	36.48
	25.11		36.1	
	25.98		38.12	
QP - 30%	30.75	29.25	37.53	37.36
	28.98		37.12	
	28.01		37.42	
QP - 40%	29.65	28.30	36.83	36.41
	26.95		35.98	

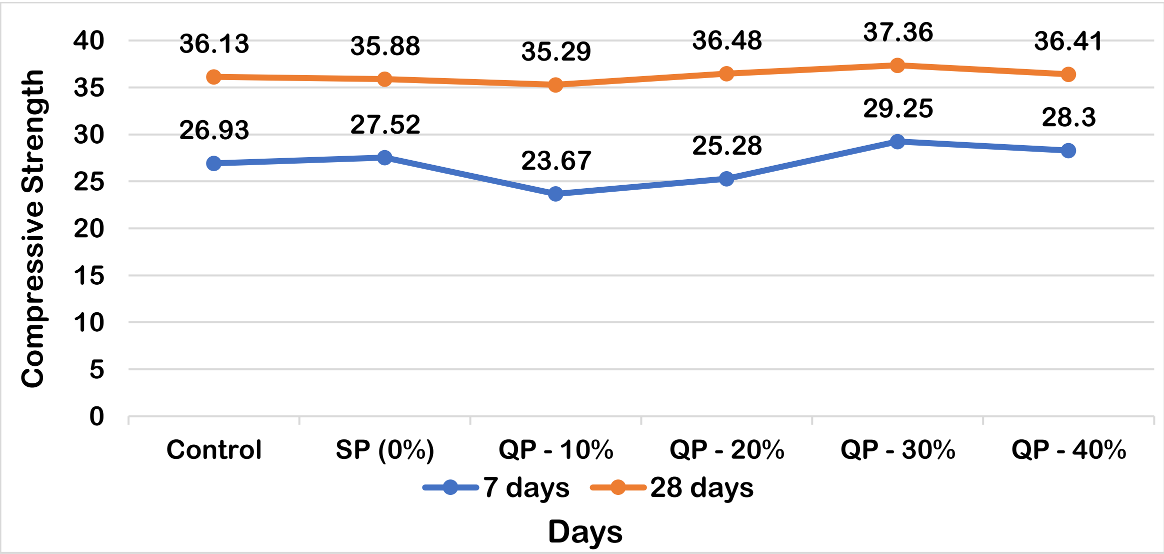

Figure 1. Relationship of Compression Force among 7 and 28 day (Major Outcome facts)

4.3 Conversation

The objective of this investigation is in order to appraise the Compression Force and fluid ability of self- compressing concrete through the incorporation of quarry powder, substituting sand at varying design proportions ranging from 10% to 40%. The conclusions of the J ring flow test and flowability tests during the initial stages of concrete design and deployment shown a notable enhancement in the self-compaction concrete. When quarry powder was added, the strength at compression improved significantly by up to 30% after seven and twenty-eight days. However, when more quarry dust is added, the compression strength decreases. Our idea made use of a chemical combination called super plasticizer. Super plasticizers of the Poly Carboxylate Ester (PCE) class are used to facilitate concrete fluidity without causing exterior vibration. When 10%, 20%, 30%, and 40% of the sand is replaced with QP, the strength at compression is reached with 30% less quarry dust. At the age (in days) 28, the compressible force value is 37.36 MPa.

5. CONCLUSION

The findings of this inquiry revealed that the flowability and compression strength of self- compressing concrete (SCC) were marginally enhanced by substituting quarry powder for sand/fine aggregate in proportion ratios of 10, 20, 30, and 40%. However, the flowability of SCC raised more with the amount of quarry powder with a substitution of 10 - 30% of quarry dust. The greatest compressible force of SCC is reached in 7 - 28 days with a substitute of 10 - 30%, and the strength of compression of SCC is reduced with additional or substitution of sand. It may be possible to substitute fine aggregate in the SCC with quarry powder. Numerous other property tests have been omitted due to time limitations, and this study suggests that more mechanical inspections be done.

In future research, it is recommended to use a mixture of quarry powder and husk rice to measure compressible force and to usage the rice trash in concrete. Other long-term mechanical characteristics, such the impact of weather and climate on self- compressing concrete and compressible force after the age (in days) 60 of water treatment, are recommended for future research.

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