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FLYASH BASED SELF COMPACTING CONCRETE BY USING RUBBER FIBERS

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ABSTRACT:

Throughout the world, the disposal of used tires is a major environmental problem causing environmental hazards such as bleeding ground for mosquitoes, producing uncontrolled fire and they are pollute & contaminating the soil and vegetation. Therefore, there is an urgent need to identify alternative outlets for these tires, with the emphasis on recycling the waste tire. Concrete is an excellent structural material and considered as essential for the modern civilization and human society. Now, the use of waste tires in concrete has become technically feasible and the concrete is being considered as light weight concrete. This study reviews the feasibility of using waste tires in the form of fibers with FR 4.75 in concrete to improve the workability as well as protecting the environment. Also it reviews the potential application in the field by exploiting its unique characteristics and properties.

In this study, we outline the use of rubber fibers in SCC in different mix ID's by using M40 grade and show how it is suitable for the concrete, its uses, benefits and way to future study. Rubber fibers are used in this study as partial replacement of coarse aggregate, in this experiment we cast cubes of 150x150x150mm size, cylinders of 150mm dia & 300 mm length and prisms of 100x100x500mm in size for 7days & 28days testing as partial replacement of coarse aggregate and testing under compression, tensile & flexure. This rubber fiber concrete is not a strength based concept, tried to protect our environment on this earth from pollutants. Rubber fiber Concrete has light weight, fire resistance, resistance from water absorption & ductility.

I. INTRODUCTION TO SELF COMPACTING CONCRETE

1.1 General

Self Compacting Concrete was first developed in 1986 in Japan to achieve durable concrete structures since then, various investigations have been carried out and mainly large construction companies have been used this type of concrete in practical structures in Japan.

SCC is a new kind of high performance concrete (HPC) with excellent deformability and segregation resistance. It is a special kind of concrete that can flow through and fill the gaps of reinforcement and corners of moulds without any need for vibration and compacting during the placing process. Though showing good performance, SCC is different from HPC developed in North America and Europe, which emphasizes on high strength and durability of concrete. In terms of workability, HPC may improve fluidity of concrete to facilitate to placing. However, it cannot flow freely by itself to pack in every corner of moulds and all gaps among reinforcement. In other words, HPC steel requires vibration and compaction in the compaction process. Comparatively, SCC has more favorable characteristics such as high fluidity, good segregation resistance and the distinctive self-compacting ability without any need for vibration during the placing process.

1.2 Development of SCC

For several years beginning in 1983, the problem of the durability of concrete structure was a major topic of interest in Japan. The creation of durable concrete structures requires adequate compaction by skilled workers. The design of modern reinforced structures becomes more and more advanced, the designed shapes of structures are becoming increasingly complicated and heavy reinforcing is no longer unusual. Furthermore the gradual reduction in the number of skilled workers in Japan's construction industry has lead to a similar reduction in the quality

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of construction work one solution for the achievement of durable concrete independent of the quality of construction work in the employment of SCC, which can be compacted into every corner of a form work, purely by means of its own weight without need for vibrating compaction. The necessity of this type of concrete was proposed by okamura in 1986. Studies to develop SCC, including a fundamental study on the workability of concrete, have been carried out by “ozawa and maekawa” at the university of Tokyo.

1.3 Benefits and Advantages of SCC

Modern, present day SCC can be classified as an advanced construction material. The SCC as the name suggests, does not require to be vibrated to achieve full compaction. This offer many benefits and advantages over conventional concrete.

- Improved quality of construction and reduction of onsite repairs.
- Faster construction times.
- Low overall cost.
- Facilitation and introduction of automatic concrete construction.
- Improvement of health and safety is also achieved through elimination of handling of vibrates.
- Substantial reduction of environmental noise loading on and around a site.
- Possibilities for utilization of “dusts”, which are currently waste products demanding with no practical application and which are costly to dispose of.
- Better surface finishes.
- Easier placing.
- Thinner concrete sections.
- Greater freedom in design.
- Improved durability and reliability of concrete sections.
- Ease of placement results in cost savings through reduced equipment and labor requirement.
- SCC makes the level of durability and reliability of the structure independent from the existing co-site conditions related to the quality of labor, casting and compacting systems available.
- The high resistance to external segregation and the mixtures self-compacting ability allow the elimination of micro-defects, air bubbles and honeycombs responsible for penalizing mechanical performance and structural durability.

1.4 How does it work

- A consolidating must have a fluidity that allows self-consolidation without external energy.
- Remain homogenous in a form during and allow the placing process and flow easily through reinforcement.

To achieve these performances, okamura redesigned the concrete mix design process.

1.5 Applications

- To shorten construction period.
- To assure compaction in the structure; especially In confined zones where vibrating compaction is difficult.
- To eliminate noise due to vibration effective especially at concrete products plants.

II. LITERATURE REVIEW

ELDIN conducted tests on rubberized Concrete behavior, using tire chips and crumb rubber as aggregate substitute of sizes 38,25mm and 19mm exhibited reduction in compressive strength by 85% and splitting tensile strength by 50% but showed the ability to absorb a large amount of plastic energy under tensile and compressive loads.

BIEL AND LEE have used recycled tire rubber in concrete mixes made with magnesium ox chloride cement, where the aggregate was replaced by fine crumb rubber up to 25% by volume. The results of compressive and tensile strength tests indicated that there is better bonding when magnesium ox chloride cement is used. The researchers discovered that structural applications could be possible if the rubber content is limited to 17% by volume of the aggregate.

Need for further research: As seen in the above Section the accumulation of used tyres at landfill sites presents the threat of uncontrolled fires, producing a complex mixture of chemicals harming the environment and contaminating soil and vegetation. There is, therefore, an urgent need to identify alternative outlets for these tyres, with the emphasis on recycling in line with the policy of most countries.

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- One such possible outlet is to produce tire chips and fibres components for use in concrete as aggregate or filler. Indeed, waste tire chips and fibre is uniquely different to other waste materials, because its production method does not require any sophisticated machineries and easy to handle in economically. Hence, the successful use of waste tire chips and fibers in concrete could provide one of the environmentally responsible and economically viable ways of converting this waste into a valuable resource.

Current research: Though rubberized concrete has proven its applications in various construction fields, still a lot of research has to be done to measure the elastic constants and mechanical properties of rubberized concretes by adding rubber in different volume proportions, water-cement ratios, aspect ratios and in different forms such as fiber chips, so that the appropriate strength can be explored. A research is underway using the grade of cement 53, to improve the strength, fine sand and coarse aggregate of a combination of 10mm and 20mm.

III. INTRODUCTION TO RUBBERIZED CONCRETE

3.1 General

The United States, among many other countries around the world, is facing many challenges regarding its waste materials. The Environmental Protection Agency (EPA) estimates that within the next 10 years, the majority of the landfills in the country will be closed. Many states and local governments face major issues regarding opening and operating new landfills due to many factors such as regulations, design modifications, and cost. One major area of concern, in some parts of the country, is the disposal of waste tires. The United States produces over 270,000,000 million waste tires each year. The EPA estimates that each person generates one waste tire per year. The state of South Carolina generates approximately 4,000,000 waste tires each year. Worldwide, the use of rubber products increases every year.

3.2 Types of Rubber used

In general there are two different types of rubber were used in concrete as partial replacement of coarse aggregate.

- Shredded rubber
- Crumb rubber
- Polypropylene

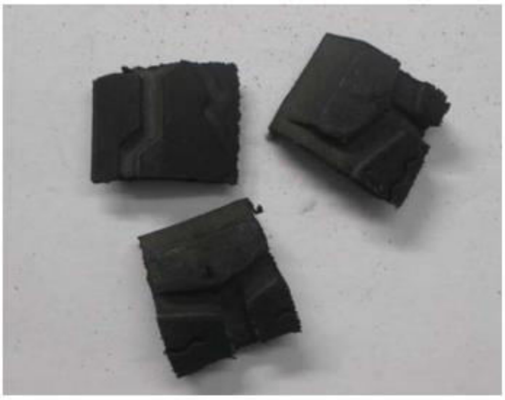

Fig-1 Shredded Rubber

3.4 Reuse and Wastage of Rubber in U.S

About 242 million tyres are discarded every year in the United States alone. Less than 7 percent are recycled. 11 percent are incinerated for their fuel value and another 5 percent are exported. The remaining 78 percent are either land filled, or are illegally dumped. According to a recent report of the US Environmental Protection Agency (U.S EPA), this has resulted in a national stockpile of over 2 billion waste tyres.

3.5 Applications and advantages

The rubberized concretes are affordable, cost effective and withstand for more pressure, impact and temperature when compare it with conventional concrete. It is observed that the RFC are very weak in compressive and tensile strength. But they have good water resistance with low absorption, improved acid resistance, low shrinkage, high impact resistance, and excellent sound and thermal insulation. Studies shows the CRC (crumb rubber concrete) specimens remained intact after failure (did not shatter) compared to a conventional concrete mix. Such behavior may be beneficial for a structure that requires good impact resistance properties.

3.6 Role of Rubberized Concrete on Environment

The wastages are divided as Solid waste disposal, Liquid waste disposal and Gaseous waste disposal. There are lots of disposal ways for liquid and gaseous waste materials. Some solid waste materials such as PET bottles, papers, steel, etc can be recycled without affecting the environment. But

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there is no way to dispose the solid wastes such as waste tires. If the tire is burned, the toxic product from the tire will damage the environment and thus creating air pollution. Since it is not a bio degradable material, this may affect the fertility of the soil and vegetation. Sometimes they may produce uncontrolled fire. Similarly, there is an another challenge to the human society is in the form carbon dioxide emission and green house emission, which are considered as another type of waste, which is threatening the universe.

IV. MATERIALS AND PROPERTIES OF SCC

4.1 Requirement for constituent materials

4.1.1 Cement

The typical content of cement is 350-450 kg/m^3.

More than 500 kg/ m^3 cement can be dangerous and increase the shrinkage.

Less than 350 kg/ m^3 may only be suitable with the inclusion of the other fine filler such as fly ash, pozzolana etc.

4.1.2 Aggregates

4.1.2.1 Sand

All normal concentrating sands are suitable for SCC. Both crushed and rounded sands can be used. Siliceous or calcareous sands can be used.

The amount of fines less than 0.125 is to be considered as powder and is very important for the rheology of the SCC. A minimum amount of fines (arising from the binders. and the sand) must be achieved to avoid segregation.

4.1.2.2. Coarse aggregate

All types of aggregates are suitable. The normal maximum size is generally 16-20 mm; however particle sizes up to 40 mm more have been in SCC. Consistency of grading is of vital importance.

Regarding the characteristics of different types of aggregate; crushed aggregates tend to improve the strength because of the interlocking of the angular particles, whilst rounded aggregates improve the flow because of low internal friction.

Gap graded aggregates are frequently better than those continuously graded, which might experience greater internal friction and give reduced flow.

4.2 Admixtures

The most important admixtures are the super-plasticizers (high range water reduces), used with a water reduction greater than 20%.

The use of viscosity modifying agent (VMA) gives more possibilities of controlling segregations when the amount of powder is limited. This admixture helps to provide a very good homogeneity and reduces the tendency to segregation.

4.3 Tests conducted on materials

Physical properties of cement

The following tests as per IS 4031-1988 are done to ascertain the physical properties of the cement. The results of the tests are compared to the specified values of IS 4031-1988.

4.3.1 Consistency:

The standard consistency of cement paste is defined as consistency, which will permit the Vicat plunger to penetrate to a point 5-7mm from the bottom of the mould, this test is done to determine the quantity of water required to produce cement paste of standard consistency. For determining the setting time, compressive strength and soundness, the % of water required to produce cement paste of normal consistency is used. Consistency depends upon the composition of cement, this test was conducted as per the procedure given in IS 4031-1988. The consistency value obtained is shown in table-4.1

4.3.2 Specific Gravity of Cement:

The specific gravity is defined as the ratio of mass (or weight in air) of a unit volume of material to the mass of the same volume of water at the stated temperature. The experiment conducted as per IS code as below.

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Cement: Priya OPC 53 grade

Wt of specific gravity bottle (empty)	W1=24.5
Wt of bottle + water	W2=73.4
Wt of bottle + kerosene	W3=64.5
Wt of bottle + kerosene + cement	W4=83.0
Wt of cement	W5=25 g

$$\text{Specific Gravity of Cement} = \frac{W5\ (W3\text{-}W1)}{(W5+W3\text{-}W4)(W2\text{-}W1)}$$

$$\text{Specific Gravity of Cement} = \frac{25(64.50\text{-}24.50)}{(25+64.50\text{-}83)(73.40\text{-}24.5)}$$

Specific gravity of cement = 3.15

Table – 4.1 results of tests on cement

Sl.No	Tests conducted	OPC-53
1	Normal consistency (%)	29%
2	Specific gravity	3.15
3	Setting time	
	a) Initial	103min
	b) Final	215min

4.5 Properties of SCC

SCC differs from conventional concrete in that its fresh properties are vital in determining whether or not it can be placed satisfactorily. The various aspects of workability which control its filling ability, its passing ability and its segregation resistance all need to be carefully controlled to ensure that its ability to be placed remains acceptable.

4.6 Properties of hardened concrete

4.6.1 Compressive Strength

In all the SCC mixes compressive strength of standard cube specimens were compared to those traditional vibrated concrete with similar water-cement ratios, if anything strengths were higher. There is little difficulty in producing SCC with characteristic cube strength up to 40 Mpa.

4.6.2 Tensile Strength

Tensile strengths are assessed indirectly by the splitting tensile test on cylinders. For SCC, the relationships between tensile and compressive strengths were of a similar order to those of traditional vibrated concrete.

V. MIX PROPORTIONING

5.1 General

To produce SCC the major work involves designing an appropriate mix proportion and evaluating the properties of the concrete thus obtained. In practice, SCC in its fresh state shows high fluidity, Self-Compacting ability and segregation resistance, all of which contribute to reducing the risk of honey combing of concrete. With these good properties, the SCC produced can greatly improve the reliability and durability of the reinforced concrete structures. In addition SCC shows good performance in compressive strength test and can fulfill other considerations that requirements in the structural design.

VI. EXPERIMENTAL INVESTIGATIONS

Experimental Program me

One SCC Mix of M40 grade with W/C 0.46 with different types of admixtures were developed in the laboratory and FR 4.75 type rubber fibers were added to these SCC mixes and Rubberized SCC was developed. The experimental program me consisted of casting and testing of SCC and RFSCC elements in compression, tension and in flexure. Cubes of 150x150x150mm Size were cast for testing in compression. Also prisms of size 100 X 100 X 500 mm were cast for testing in flexure under two point loading and also cylinders (150mm diameterx300mm height) testing for splitting tensile test.

6.1 Brief description of the project work:

The present investigation was aimed to study the mechanical property and flexural behavior of SCC and RFSCC.

For these

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- SCC mixes were developed in the laboratory with help of Nan Su Method of mix design & different guidelines using different mineral and chemical add mixtures.

- Rubber Fiber for SCC was added to these mixes and RFSCC was developed.

- SCC & RFSCC were tested in fresh state to find filling ability, passing ability and segregation resistance of mixes.

- After testing in fresh state SCC and RFSCC were poured in moulds of cubes, cylinders, prisms and demoulded after 24 hours & cured for 7, 28 & 56days.

- These specimens were tested in compression, tension and in flexure and results in hardened state were observed and studied.

6.2 Testing of SCC in fresh state

Since SCC will not use external consolidation (by definition), the behavior of concrete while in the fresh state will determine the quality of placement. Thus, if a concrete displays signs of segregation to is insufficient in its flow ability or deformability while fresh, the concrete will not perform in the manner it should and will most likely result in a poor quality hardened concrete. The tests that have been developed by others that allow a user to define a concrete as SCC or not are, at this time not yet incorporated (deformability, flow ability and segregation resistance) of SCC have been under development since the introduction of SCC. The quantities differ according to the type of construction and any specific requirements that must be net. Examples of these tests include the Slump flow, L--Box, V-Funnel, Orimet and J-Ring. Following figures shows examples of some of these tests.

6.3 Slump Flow & T_{50}

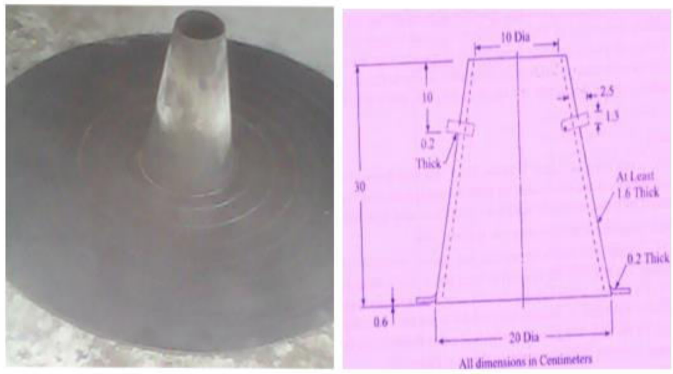

Fig 4 & 5 - Slump cone with dimensions

Fig – 6 A photo shown slump value

Slump flow is definitely one of the most commonly used SCC test at the current time. This test involves the use of the slump cone used with conventional concrete. The main difference between the slump flow test measures the “spread” or “flow” of the concrete sample once the cone is lifted rather than the traditional “slump” (drop in height) of the concrete sample. The T50 test is determined during the slump flow test; it is simply the amount of time that the concrete takes to flow to a diameter of 50 centimeters. Typically, slump flow values of approximately 24 to 30 inches are within the acceptable range, acceptable T50 time range from 1 to 25 seconds.

VII. **RESULTS AND DISCUSSION**

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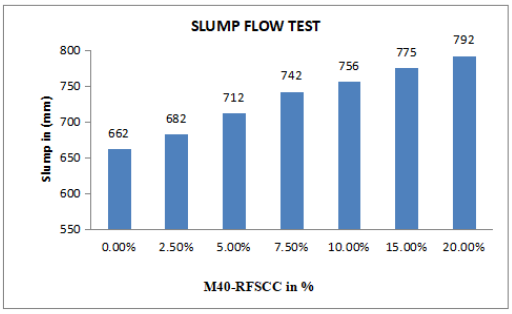
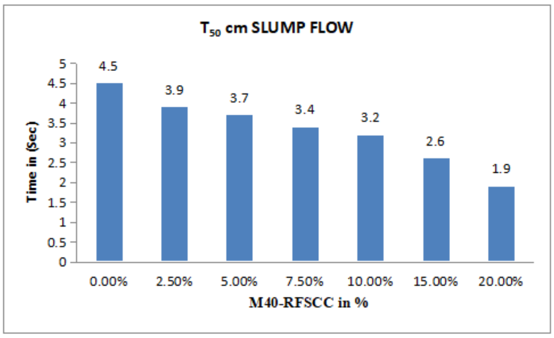
Fresh concrete properties of SCC and RFSCC in different mix proportions





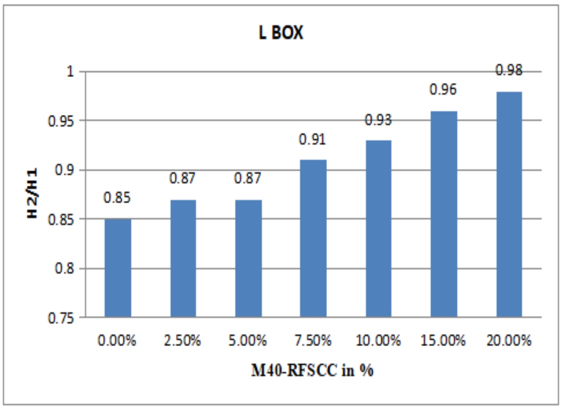


Table-7.1 Compressive Strength & Comparison at 7, 28 and 56 days for SCC and RFSCC Elements-M40 grade

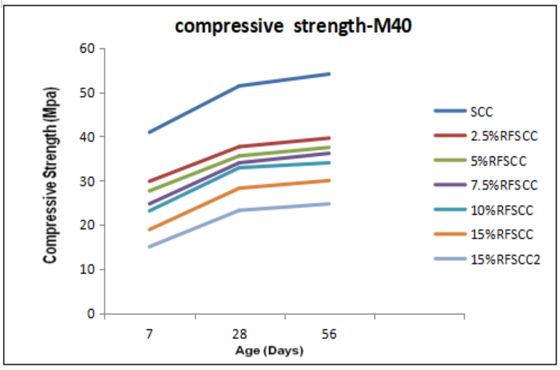
mix id	Rubber fiber in %	Compressive strength in (Mpa)			Comparison RFSCC with SCC (%)		
		7 Days	28 Days	56 days	7 Days	28 Days	56 days
SCC	0	40.9	51.38	54.07	-	-	-
RFSCC-1	2.5	29.79	37.63	39.57	-27.16	-26.76	-26.81
RFSCC-2	5	27.61	35.54	37.45	-32.49	-30.82	-30.73
RFSCC-3	7.5	24.69	33.98	36.12	-39.63	-33.86	-33.19
RFSCC-4	10	23.09	32.86	33.98	-43.54	-36.04	-37.15
RFSCC-5	15	18.85	28.23	29.95	-53.91	-45.05	-44.6
RFSCC-6	20	14.98	23.21	24.68	-63.37	-54.82	-54.35

Table-7.2 split tensile Strength & Comparison at 7, 28 and 56 days for SCC and RFSCC Elements-M40 grade

Mix Id	Rubber fiber in %	Compressive strength in (Mpa)			Comparison RFSCC with SCC (%)		
		7 Days	28 Days	56 days	7 Days	28 Days	56 days
SCC	0	2.48	3.46	3.66	-	-	-
RFSCC-1	2.5	2.13	2.46	2.58	-14.11	-28.9	-37.7
RFSCC-2	5	2.02	2.28	2.38	-18.54	-34.1	-42.07
RFSCC-3	7.5	1.96	2.12	2.21	-20.96	-38.72	-39.61
RFSCC-4	10	1.78	1.98	2.08	-28.22	-42.77	-43.16
RFSCC-5	15	1.45	1.75	1.83	-41.53	-49.42	-50
RFSCC-6	20	1.12	1.52	1.59	-54.83	-56.06	-56.55

Table-7.3 Flexural Strength & Comparison at 7, 28 and 56 days for SCC and RFSCC Elements-M40 grade

Mix Id	Rubber fiber in %	Flexural strength in Mpa			Comparison RFSCC with SCC (%)		
		7 Days	28 Days	56 days	7 Days	28 Days	56 days
SCC	0	10.66	13.32	14.06	-	-	-
RFSCC-1	2.5	9.07	11.36	11.89	-14.91	-14.71	-15.43
RFSCC-2	5	8.82	10.64	10.9	-17.26	-19.96	-22.47
RFSCC-3	7.5	7.99	9.81	9.97	-25.04	-26.35	-29.08
RFSCC-4	10	7.19	9.21	9.85	-32.55	-30.85	-29.94
RFSCC-5	15	6.65	7.65	8.12	-37.61	-42.56	-42.24
RFSCC-6	20	5.96	6.65	7.12	-44.09	-50.07	-49.35



CONCLUSIONS

Conclusions

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- Ease of preparation and finishing was also assessed. It was found that rubber fiber concrete mixes did not pose any difficulties in term of finishing, casting, or placement, and that a good quality finish can be achieved although additional effort is required to smooth the finish surface.

- The test results show that the use of rubber aggregate in OPC concrete mixes produces a significant reduction in concrete compressive strength which increases with increasing rubber fiber content.

- The various rubberised concrete mixes were designed in accordance with standard mix design procedures for SCC with a 40 MPa target compressive strength. As expected, the target strengths were not achieved for the mixes incorporating rubber fiber. However, concrete mix design is approximate and any concrete batch must be tested to ensure that the specified properties are achieved.

- FRSCC is light weight, acid resistance, economical, more workability and mainly eco-friendly.

- The rubber fiber is very less cost with compare to aggregate and it will be found at various retreading & tyres manufacturing companies, we use disposed rubber waste for the casting of cubes, cylinders & prisms in the laboratory. Advantage in this project is economical but strength is less than permissible of SCC.

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