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EXPERIMENTAL INVESTIGATION ON FLEXURAL BEHAVIOUR OF LATEX MODIFIED SILICA FUME BASED RC BEAM

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***Abstract*—** The motivation behind the test examination is to describe the flexural and mechanical conduct of fortified solid bar with Poly Acrylic Ester (PAE) Latex and silica rage as incomplete swap for concrete. The latex changed cement are to be set up with different polymer-cover proportions with steady 15% silca seethe content substitution by volume of concrete. The percentage of latex content were varied as 7.5, 12.5 and 17.5 by the mass of binders (Cement and Silica fume). The optimum latex content is to be obtained from compression test results. A beam will be casted and tested with optimized latex modified concrete & control sample to elevate variations in its flexural & mechanical behavior as compared to control sample.

***Keywords*—** *Poly Acrylic Ester (PAE), Silica Fume, Mechanical Properties, Flexure, Replacement*

I. INTRODUCTION

Concrete is a composite material with low unbending nature and delicate impact block. Regardless, it is one of the most by and large used improvement materials due to its high compressive quality and negligible exertion. Concrete utilized in pressure driven structures is continually introduced to unforgiving marine condition all through the whole year, which ordinarily prompts genuine debasement after turn of events, for instance, developing, spalling, and breaking of the spread cement. The related assessments have pointed out that the debilitated solid structures with first rate concrete based fix materials are an effective and realistic way to deal with grow their organization life conversely with the revamping of the structures. Along these lines, fix materials with a superb mechanical introduction are unimaginably mentioned. (Park *et al*., 2005).

Polymers have been used for improving mechanical properties, hold with substrates, and waterproofing properties of mortars and concretes. The solid mortar and concrete made by mixing in with the polymer based admixtures are called polymer balanced mortar and polymer adjusted concrete independently. Polymers, for instance, styrene–butadiene flexible (SBR), polyacrylic ester (PAE), styrene–acrylic ester (SAE), and vinyl acidic corrosive induction ethylene (VAE) have been utilized in mortars and concrete. Regardless, research showed that the joining of polymer would all in all diminish the compressive nature of cementitious materials. Starting late, PAE has expanded more application and has been exhibited to improve diverse structure properties of mortars and concretes, for instance, handiness, water ingestion, flexural quality, and split resistance.

Pozzolanic materials can generally substitute Portland concrete to update the properties of concrete and mortars, for instance, master and strength related properties. Silica fume (SF) is an advanced result and has been commonly used as mineral admixture in concrete and mortar, generally to improve the mechanical properties and reduce the porosity. Also, its durability properties, for instance, sulfate resistance, chloride iron impermeability, and freeze-defrost check could similarly be overhauled.

II. The right blend of silica seethe and polymeric emulsions may bringing about a development material with great execution for some application. The silica smoke and polymer latex extension can improve the mechanical properties of concrete. The effect of PAE and SF on the mechanical properties of concrete, for instance, the compressive, Indirect versatile, and flexural quality is to be inspected.

III. LITERATURE REVIEW

The part presents the short audit of writing relating to the conduct of polymer latex and silica seethe in mortar and cement.

A. Literature Review

Abdel-Fattah *et al*., (1999) The flexural conduct of polymer solid (PC) made with various kinds of tars was assessed in this examination. The contemplated boundaries remembered the level of polymer for the solid blend. Three rates were utilized: 9, 12 and 15%, and the fortification proportion 0, 0.0042 and 0.0116. The outcomes show that the modulus of crack and extreme compressive strains for PC are a lot higher than that of common Portland concrete cement. The shafts demonstrated an exceptionally malleable conduct and high malleability factors were acquired.

Alessandra *et al*., (2006) Preliminary assessment on the effect of styrene acrylic polymer and silica rage on the mineralogical structure pf stuck of high-early-quality Portland solid after 28 days of anticipating are presented in this paper. The results showed that the extension of silica smoke and polymer reduces the portlandite improvement due to delaying of Portland solid hydration and pozzolanic reaction.

Bordeleau *et al*., (1992) Latex changed cements were set up with 7.5 and 15 percent of strong polymer-to-solidify proportion. Three distinctive water-concrete proportions were utilized: 0.30, 0.35, and 0.40. The outcomes additionally show that a regular cement with a decent air-void separating factor and a low water-concrete proportion can be nearly as impervious to salt scaling as latex-changed cement.

Chandra (1987) Cooperation of polymers and other natural admixtures on Portland concrete hydration is assessed. It is presumed that polymers and natural admixtures cooperate with the parts of Portland concrete when they interact with water. This association is because of ionic holding, causing cross-joins which restrain the film development property of polymers and impact significantly the crystallization cycle during the solidifying of cement.

Chen *et al*., (1996) Mortars containing carbon, polyethylene, and treated steel filaments at a similar volume division and with comparative fiber breadths were analyzed as far as pliable, compressive, and flexural properties. The tractable, compressive, and flexural qualities and flexural durability were totally expanded by latex expansion for any fiber type.

Gao *et al*., (2012) This paper inspected the flexural and the compressive characteristics of polyacrylic ester (PAE) emulsion and silica fume (SF)- changed mortar. The results show that the reducing in porosity and addition of thickness of solid mortars can be refined by the pozzolanic effect of SF, the water-lessening and - filling effect of polymer. Lower porosity and higher thickness can give solid mortars such properties as higher flexural and compressive quality, higher scaled down hardness regard in interfacial zone and lower convincing dispersal coefficient of chloride molecule in structure.

Gorninski *et al*., (2004) The primary point of this examination is to survey the modulus of flexibility of polymer solid (PC) mixes created utilizing two kinds of covers: orthophtalic or isophtalic polyester. The arrangements utilized were chosen from a past report that distinguished financially savvy PC structures. Fly debris was utilized as a filler and sytheses with 8%, 12%, 16% and 20% of debris by weight of total were examined.

Kardon (1997) Composites of concrete and polymers of various sorts are used in various applications. This paper rapidly overviews the recorded scenery of polymers in mix with concrete as a structure material, where the polymer isn't as fiber or work reinforcing, anyway as a polymerized system intermixed with the hydrated solid paste. The microstructure and properties of the composite polymer-changed concrete are depicted, and some current and possible future applications are referred to.

Larbi, *et al*., (1990) The instrument of communication of polymers with the hydration results of portland concrete has been considered. The information were acquired by crushing the pore arrangements from concrete glues with a fitting pore arrangement articulation gadget, followed quickly by synthetic

examinations of the reasonable arrangement. Three latexes - a styrene acrylate, a styrene acrylate with a coupling operator, and a polyvinylidene chloride were utilized for the examination. The examination additionally uncovered that measurements of 5% or a greater amount of polyvinylidene chloride (v/v of concrete composite) could deliver adequate Cl-particles to surpass the decent consumption limits in fortified cement.

Mirza *et al*., (2002) The results of a constant test program to overview the presentation of polymer adjusted concrete based mortars for fixing surfaces of solid structures to a criticalness of 75mm were spoken to in this appraisal. 25 picked monetarily open polymer balanced things, 7 containing styrene butadiene adaptable (SBR) and 18 containing acrylics were assessed. They were separated and those of unadulterated concrete based mortar containing 8% silica rage by wt of concrete, with W/MC (Concrete + silica rage) degree of 0.31.

Nagaraj *et al*., (1987) explored super-plasticized characteristic elastic latex altered cement from their reports, it can been seen that for evaporate elastic substance to 2% the greatest compressive and rigidity stay unaltered, contrasted with that of plain concrete, however with articulated increment in the strain limit. It was reasoned that with characteristic elastic latex as an admixture the flexibility of the solid upgraded with the maintenance of solidarity level of plain concrete; 2% dry elastic substance has been found to instigate ideal degrees of progress in pliable conduct without decrease in compressive quality of plain cements.

Ohama *et al*., (1997) This review deals with the continuous progression of upgrades in strong polymer composites, which are requested into three sorts: polymer-adjusted (or solid) mortar (PMM) and concrete (PMC), polymer mortar (PM) and strong (PC), and polymer-impregnated mortar (PIM) and strong (PIG). An unprecedented eagerness for the strong polymer composites is starting at now based on high-grade redispersible polymer powders, fix and sturdiness improving materials for reinforced strong structures, huge scope producing systems, automated cast set up application structures, fake marble things, machine instrument structures, and field polymer impregnation systems.

Ohama (1998) The possibility of polymer modification for solid mortar and concrete isn't new, since amazing inventive work of polymer change have been performed for up to 70 years or more. Along these lines, diverse polymer-based admixtures have been made, and polymer-balanced mortar and strong using them are correct now acclaimed improvement materials by virtue of their extraordinary cost-execution balance. This article summarizes the gathering of polymer-based admixtures, the guidelines of polymer modification by the use of polymer latexes, redispersible polymer powders, water-dissolvable polymers and liquid polymers, the properties and employments of polymer-adjusted mortar and strong, progressing creative work activities, and standardization work.

Ohama (2011) The current paper deals with the guidelines of cycle development for strong polymer composites, the inventive work history of the strong polymer composites, the continuous examples in the creative work of the strong polymer composites and the current status of noteworthy standardization work for the strong polymer composites, in view of thorough composing diagram. The future examples in the inventive work of the strong polymer composites are envisioned, and efficient strong polymer composites are proposed for the 21st century.

Park *et al*., (2005) This paper presents the test concentrate for the flexural conduct of fortified solid pillars fixed by Polymer Concrete Mortar (PCM) and Customary Portland Concrete Mortar (OPCM) in the strain district. Tests were performed for eight fortified solid pillars with differing support proportions, fix materials and fix lengths. Accentuation is given to in general bowing limit, diversion, malleability record, disappointment mode and break advancement of fixed bars. The outcomes are contrasted and those from the control pillar.

Prasad *et al*., (2008) In this paper result of an experimental investigation carried on cylindrical specimen of latex modified concrete (LMC) under cyclic compressive loading are present. The LMC was made using 5, 10, and 15 percent of polymer admixture of the cement mass. The parameters considered for the study are latex dispersion, water cement ratio and the concrete strength. Based on the experimental investigation subjected to slow cycle fatigue compressive loading conclude that in all LMC specimen at lower value in axial strain of 15% latex compared to 5%, 10% latex content. The overall performance of LMC under slow cycle fatigue loading improves with addition of latex up to 10% of only. Such improvement is not observed with addition of 15% latex.

Reis (2005) Mechanical portrayal of epoxy polymer concrete strengthened with characteristic strands is examined in this work to break down the chance of replacement by manufactured filaments. These regular strands considered are coconut, sugar stick bagasse, and banana filaments. These strands originate from their particular items after they have been utilized, for example as reuse. As the common strands are farming waste, fabricating regular item is, in this way, a monetary and fascinating alternative. The primary thought is to utilize the strands like they originate from nature with no sort of planning.

Rebeiz *et al*., (2004) This paper explores the utilization of fly debris as a swap for sand in polymer solid PC. It is demonstrated that a substitution of 15% by weight of sand with fly debris improves the compressive quality of unreinforced PC chambers by about 30% and the flexural quality of steel-strengthened PC radiates by about 15%. Different upgrades in properties are moderately minor and incorporate the tractable security quality of PC under warm cycling and the drag consistence of the PC under supported stacking.

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Shaker *et al*., (1997) The primary target of this examination to explore and assess the principle sturdiness parts of Styrene-Butadiene latex altered cement (LMC) contrasted with those of regular cement. Likewise, the primary microstructural attributes of LMC were contemplated utilizing an Examining Electron Magnifying instrument (SEM). The SEM examination of the LMC demonstrated significant contrasts in its microstructure contrasted with that of the traditional cement. The LMC end up being better in its sturdiness looked at than the strength of regular cement particularly its water snugness (estimated by water entrance, ingestion, and porosity tests), scraped spot, erosion, and sulfate opposition.

Saccani *et al*., (2001) The impact of polymer expansion of antacid silica responses in cementitious mortars containing high salt focuses has been examined. A bi segments epoxy gum was added to the mortars detailing up to a 20% wt of concrete substance. Mechanical Properties were examined. As the polymer content builds mortar development is decreased.

Vipulanandan *et al*., (1993) The compressive and pliable properties of polyester polymer and polymer concrete were concentrated under different restoring conditions, temperature, and strain rate. The impact of test factors on the mechanical properties of polymer and polymer concrete are measured. The compressive quality of polymer and polymer concrete are identified with their compressive modulus and parting rigidity. A constitutive model is utilized to anticipate the compressive pressure strain conduct of polymer and polymer concrete.

Yang *et al*., (1992) The development to set mortar of 0.37 volume% of short, pitch-based carbon fibers, alongside latex (styrene-butadiene) and antifoam, extended the flexural quality by 54% and the compressive quality by 30% at 28 days of diminishing. The ideal latex/solid extent was 0.2. The latex served to dissipate the fibers and augmentation the holding between the strands and the cross section.

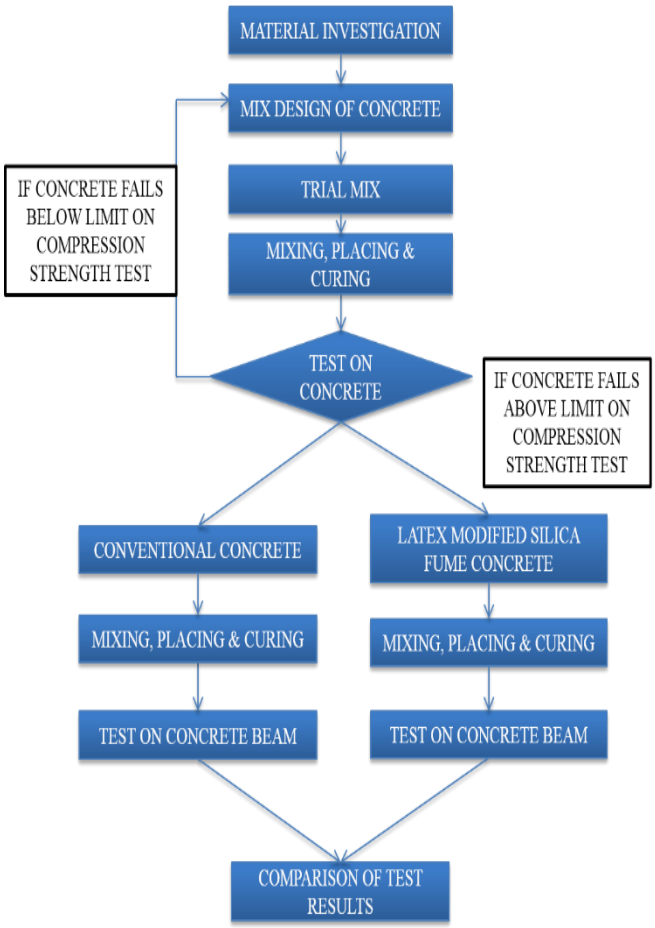
Conclusions From Literature Review

The following points were observed from the extensive literature study which are to be used in this study

- The modulus of burst and extreme compressive strains for Polymer concrete are a lot higher than that of customary cement.
- Abatement in porosity and increment in thickness can be accomplished by the pozzolanic impact of Silica smolder, the water-lessening and filling impact of polymer.
- The tensile, compressive, and flexural strengths and flexural toughness of concrete increased by latex addition.
- Poly Acrylic Ester (PAE) Latex can be used as Polymer admixture and Silica Fume (SF) as mineral admixture.
- Hence in the study it is proporsed to evaluate the mechanical and flexural behavior of the concrete using the above admixtures PAE & SF as compared with the conventional concrete.

IV. METHODOLOGY

The general method used for conducting tests on the raw materials for concrete, strength aspect in casting concrete specimens and conducting the tests are done as per the corresponding codal procedures. The examples will be tried following 7 days, 14 days and 28 days of restoring from the date of projecting.



V. EXPERIMENTAL PROGRAM

A. *Materials Used*

Concrete Portland Pozzalana Concrete (PPC) (Fly Debris Based) of Evaluation 33 adjusting to IS 1489 (Section 1) - 1991 is utilized in this exploratory work.

Fine Total It adjusts to IS 383 1970 goes under Zone II. Sand with portion going through 4.5 mm strainer and held on 60 micron sifter is utilized and had be tried according to IS 2386 (Section 1) – 1963 for explicit gravity and water ingestion.

Coarse Total The size of 20mm rakish coarse total has been chosen for the investigation. The physical properties had tried according to IS 2386 (Section 1) – 1963.

Silica Fume It conforms to IS 15388 having less than 1 μm in size and 2.2 specific gravity.

Polymer Latex Poly Acrylic Ester is a milk white emulsion fluid with 2–6 pH esteem and 39%–41% strong substance.

Mix Design

- Cement = 379.15 Kg/m^3
- F.A = 610.97 Kg/m^3
- C.A = 1144.13 Kg/m^3
- W/c Ratio = 0.52

- Mix Design Ratio = **1:1.61:3.01**

B. Testing Procedure

- **COMPRESSIVE STRENGTH TEST**

The test was led according to **IS 516-1959**. The examples were kept in water. During testing surface dry conditions were acquired by cleaning water on a superficial level. The store was applied without and extended tirelessly at a movement of generally 140kg/cm2/min until the resistance of the guide to the growing burden isolates and not any more vital weight can be upheld. The best weight applied to the model was then recorded and the Presence of the strong for any interesting features in such a failure was noted. Normal of three qualities was taken as the delegate of the clump.

Fig. 1. Compressive Strength Test

- **INDIRECT TENSILE STRENGTH TEST**

The test was coordinated by IS 5816-1999. The versatility of concrete is one of the basic and noteworthy properties. Separating versatility on strong chamber is a method to choose the Circumlocutory unbending nature on strong chamber.

The strong is outstandingly slight in strain in light of the feeble nature and isn't needed to contradict the prompt weight. The strong makes breaks when presented to manageable forces. Consequently, it's essential to determinate the flexibility to choose the stack at which the strong people may break.

FLEXURAL STRENGTH TEST

For determining the flexural strength of concrete a RC beam specimen of size 150mm x 150mm x 1000mm had casted. An auxiliary stacking outline had been utilized for the test. The testing machine might be set to any solid sort of adequate limit with respect to the test. Admissible blunders ought to be not more noteworthy than – 0.5%.

The flexural quality or modulus of break ought to be determined utilizing the equation given below

$$f_b = \frac{(PL)}{(ad^2)}$$

Where a is the distance between support and the crack (mm),

d is the measured depth (cm),

L is the length (mm) of the range on which the example is upheld,

furthermore, P is the greatest all out burden (N) applied to the example.

Fig. 2. Indirect Tensile Strength Test

Fig. 3. Flexural Strength Test

VI. Results and Discussions

- **COMPRESSIVE STRENGTH TEST**

The compressive quality of traditional solid, latex changed cement and latex adjusted cement containing distinctive level of latex were introduced beneath. It was seen that the latex adjusted solid example indicated multi day normal compressive quality of the request 23.23 N/mm2, 24.30 N/mm2 and 23.26 N/mm2 at the latex substance of 7.5%, 12.5%, and 17.5% separately.

The compressive strength of 7 days cubes comparing the 28 days cube shows early increment of strength due to the latex and silica fume combination. Based on the better increment of compression strength LMSFC - 12.5% is selected as optimum % of latex.

TABLE I. COMPRSSIVE STRENGTH RESULTS

		7 DAYS	**28 DAYS**

Sl .No	Sample	Comp Strength in N/mm 2	% of +/- in Comp Strength	Comp Strength in N/mm2	% of +/- in Comp Strength
1	CC	14.20	-	22.67	-
2	LMSFC - 7.5%	15.92	+12.11	23.23	+2.49
3	LMSFC - 12.5%	17.05	+20.07	24.30	+7.17
4	LMSFC - 17.5%	16.77	+18.10	23.26	+2.62

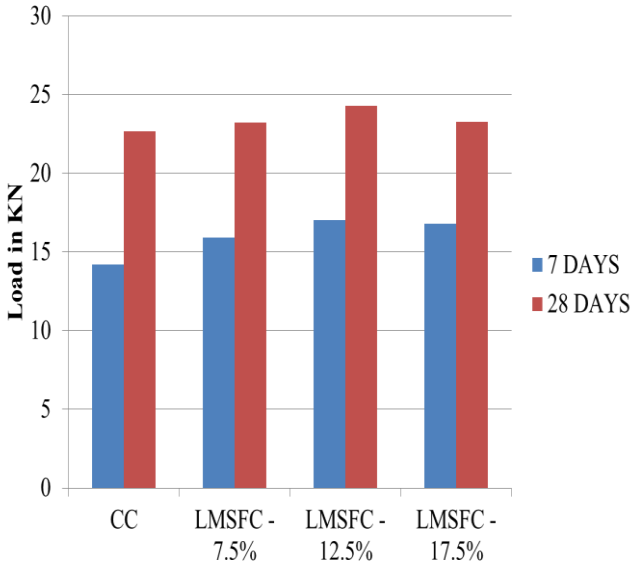


Fig. 4. Compressive Strength Results

- **INDIRECT TENSILE STRENGTH TEST**

TABLE II. INDIRECT TENSILE STRENGTH RESULTS

Sl. No.	Sample	7 DAYS		28 DAYS	
		Indirect Tensile Strength in N/mm 2	% of +/- in Indirect Tensile Strength	Indirect Tensile Strength in N/mm 2	% of +/- in Indirect Tensile Strength
1	CC	1.90	-	2.34	-
2	LMSFC - 7.5%	1.72	-9.47	2.21	-5.38

3	LMSFC - 12.5%	1.84	-3.20	2.40	+2.35
4	LMSFC - 17.5%	1.76	-7.22	2.22	-5.16

- **FLEXURAL STRENGTH TEST**

TABLE III. FLEXURAL STRENGTH RESULTS

SI. No	**Sample**	**28 Days**	
		Ultimate Load in KN	**Flexural Strength in N/Sqmm**
1	M20 – CC	95.89	12.78
2	12.5% - LMSFC	102.74	13.69

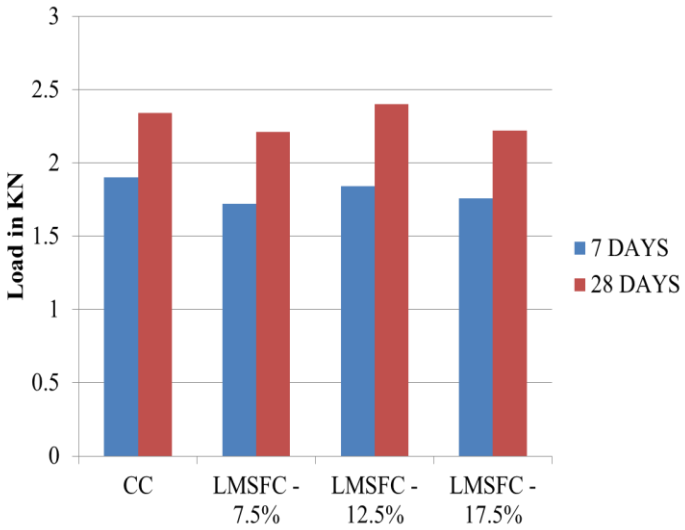


Fig. 5. Indirect Tensile Strength Results

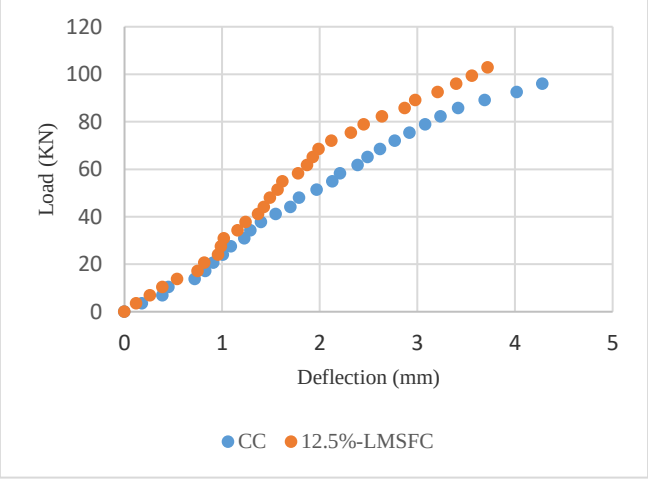


Fig. 6. Load Vs Deflection

CONCLUSION

Comparing the results of mechanical properties of conventional and latex modified silica fume concrete shows better results in compressive strength due to the combination of latex and silica fume content. But indirect tensile strength of latex modified silica fume concrete shows less results comparing the conventional concrete. Whereas the Properties such as flexural strength shows much improvement in the latex modified silica fume concrete while comparing the conventional concrete and shows better flexural behavior in load vs deflection graph.

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