Fresh, Strength and Durability Characteristics of Binary and Ternary Blended Self Compacting Concrete

Abdul Razak B. H., D. L. Venkatesh Babu

***Abstract:** Paper Mineral admixtures being the economical alternatives to Ordinary Portland Cement (OPC) for various normal and special concretes induce desirable properties to concrete such as higher flow, low heat of hydration, higher strength gain and enhanced durability. Ground granulated blast furnace slag(GGBFS) being one of the largely used mineral admixture alongside Fly Ash as supplementary cementitious material in concrete contributes to enhanced durability properties and low heat of hydration. Various replacement percentages of GGBS at 30%, 40%, 50% and 60% are used in binary blended Self compacting concrete(SCC) in the present study. At 40% replacement level, SCC exhibited improved workability, strength and durability properties. Alccofine(Ultrafine GGBS) used in ternary blended SCC enhanced early strength gain without affecting workability of SCC to a significant extent.*

***Keywords :** Ground granulated blast furnace slag(GGBFS), Alccofine, Ordinary Portland cement(OPC).*

I. INTRODUCTION

With the advancement in construction sector and requirement of structures with high load carrying capacity yet slender structural elements, conjusted reinforcement has become inevitable over the decades. Self compacting concrete(SCC) being more suitable for such situations, it has gained higher importance. Replacing Ordinary Portland cement(OPC) with different mineral admixtures which serve the purpose of lower cost, lower hydration heat and enhanced durability properties [10] without sacrificing concrete strength. Mineral admixtures such as Fly Ash (FA) and GGBS are being extensively used at higher replacement to OPC for the production of various types of concrete. However mineral admixtures such as Silica Fume and Micro silica, Ultra fine GGBS(Alccofine) are among the alternatives for OPC more commonly used in ternary blended mixes to improve initial strength gain of concrete(2). GGBS and Alccofine being the low cost mineral admixtures largely available in market are used for the present study. The present study deals with the workability, hardened properties and durability properties of Self compacting blended concrete with usage of GGBS and Alccofine (Ultra fine GGBFS) as partial replacement to OPC in producing Self compacting concrete.

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II. LITERATURE SURVEY

Previous studies on blended concretes have been done using various mineral admixtures such as GGBS, Fly Ash in higher proportion and Silica Fume, Alccofine, Metakaoline mostly in ternary mixes. Some studies were conducted using fibers in the blended concretes [1].

The following observations were made in the previous studies.

- SCC made with Fly ash and Alccofine with addition of steel fibers at Alccofine content at 10% showed better strength compared with mixes with different proportion of Alccofine [1],[2],[5]. There was also improvement in durability properties of such SCC [1].
- Metakaoline being used as a mineral admixture exhibited optimum fresh properties at a replacement level of 10% [3]. Furthermore it reduced the crack width in concrete as observed in Scanned Electron Microscope (SEM) analysis[3].
- Micronized Calcite used in SCC with Low lime Fly Ash and GGBS as partial replacement for total aggregates enhancedSCCs' flowability, ability to pass and viscosity.T he replacement levels were at 5% and 10% of total aggregates[4].
- Fly Ash and GGBFS when used in SCC showed enhanced results with respect to Workability, hardened and durability of concrete compared to other supplementary cementitious materials basalt powder and marble powder. At a replacement level above 40%, concretes with GGBFS showed improved resistance to chloride ion penetration [6],[7].
- Silica fume when used in ternary blended concretes improves strength of concrete in comparison with binary blended concretes with OPC and GGBS [7].
- Concrete made without compaction such as SCC shows improved carbonation and sorptivity coefficient compared with compacted specimens [8].
- Sorptivity coeffients of low strength concretes depend mainly on curing condition [9].

III. MATERIALS AND EXPERIMENTAL WORK

3.1Materials used in the study

Binder: OPC 53 Grade, GGBFS, Alccofinen Coarse Aggregates: 12.5 mm graded b Fine Aggregates:
Manufactureds and Chemical Admixtures: PCE based Chemical Admixtures

3.2 Experimental Work

3.2.1 Mixes and designations

Designation	Mix
S0	100% OPC
S1	70% OPC+ 30% GGBS
S2	60% OPC+40% GGBS
S3	50% OPC+50% GGBS
S4	40% OPC+60% GGBS
S5	65% OPC+25% GGBS+5 % Alccofine
S6	55% OPC+35% GGBS+5 % Alccofine
S7	45% OPC+45% GGBS+5 % Alccofine
S8	35% OPC+55% GGBS+5 % Alccofine

3.2.2Fresh properties of SCC

Fresh properties of SCC such as Slump Flow, L Box Test, J Ring Test, and V funnel test were conducted to determine passing ability, filling ability and segregation resistance of concrete. The tests conform to EFNARC 2002 and EFNARC 2005 guidelines.

3.2.3Strength of concrete

Cube compressive strength of concrete at 7 and 28 days was studied.

3.2.4Durability tests of concrete

3.2.4.1 Rapid Chloride penetration test of concrete (RCPT) as per ASTM C 1202-10

Cement concrete's durability is characterized as its ability to withstand weathering, chemical attack, abrasion,or any other deterioration process. When exposed to its environment, du rable concrete should maintain its original shape, consistenc y and serviceability. Durability of SCC specimens was assessed by means of following tests:

Fig 1.RCPT testing instrument

3.2.4.2 Sorptivity as per ASTM:C 1585-04 [17]

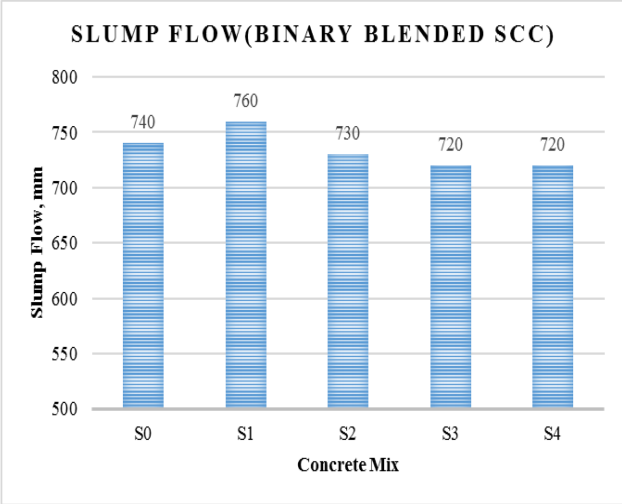
Sorptivity:To assess the rate of water absorption (Sorptivity) during initial contact with water by incoming unsaturated, c ontrolled by capillary suction.

Sorptivity in mm $I=m_1/A/d$ where d is Density of water 0.001 g/mm^3 , m_1 is Change in mass at time t_1, 'A' is c/s area in mm^2. Size of specimen used was 100 mm dia X 50mm height.

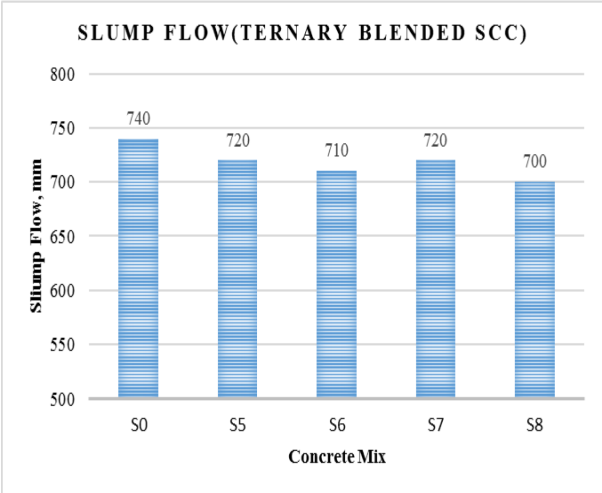
IV. RESULTS AND DISCUSSIONS

4.1 Fresh properties of SCC

4.1.1Slump flow by Abram's cone (filling ability)



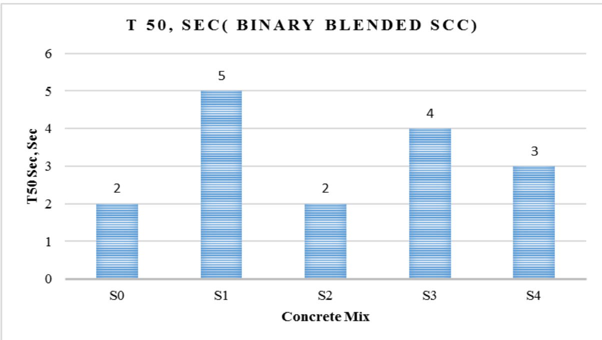
Graph 1: Slump Flow of Binary blended concrete



Graph 2. Slump Flow of ternary blended concrete

Discussion: All the blended mixes satisfy the requirement for all normal applications as per EFNARC guidelines with respect to slump flow.

4.1.2 T_{50CM} seconds (filling ability)



Graph 3.T_{50CM} SECONDS of binary blended SCC

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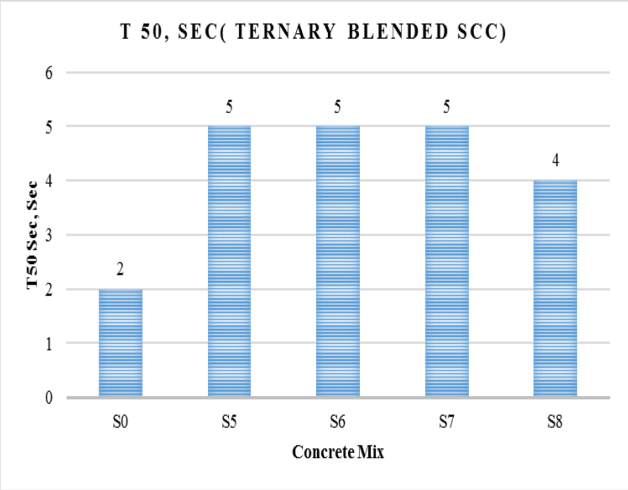
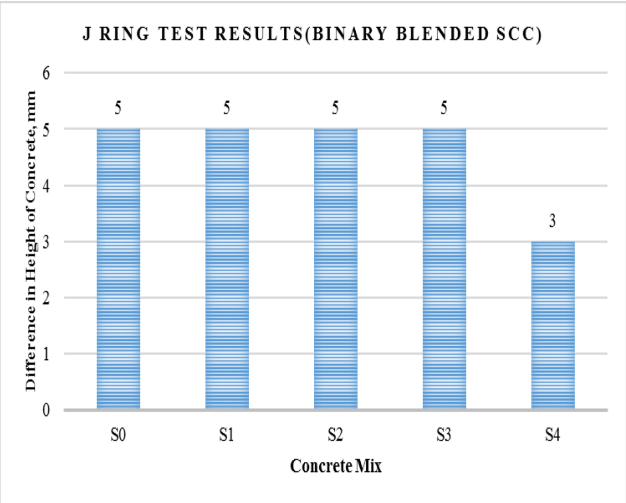


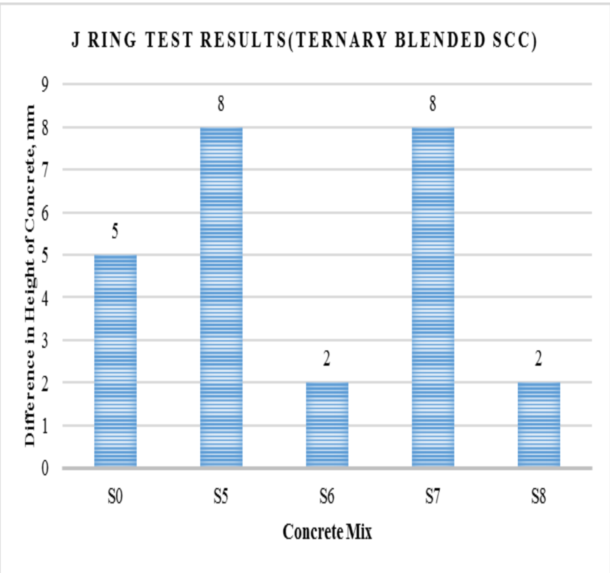
Graph 4. T 50CM SECONDS of ternary blended SCC

Discussion:
Mixes S0 and S2 demonstrate strong ability to fill even wit h congested reinforcement. It can lift itself and typically has the best surface finish. Nevertheless, bleeding and segregati on are more likely to suffer.

4.1.3 J-Ring test values (Passing ability)

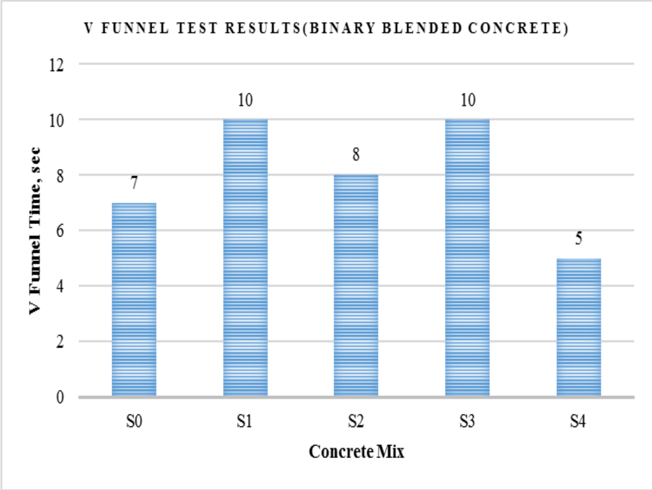


Graph 5. Passing ability test results of binary blended SCC

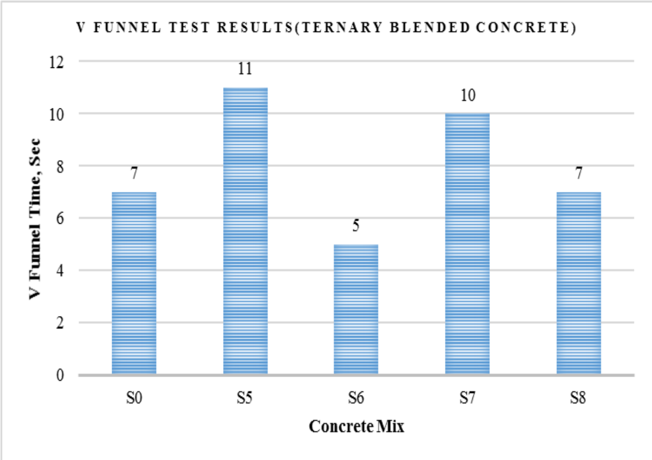


Graph 6. Passing ability test results of ternary blended SCC

4.1.4 V Funnel test values (Filling ability)



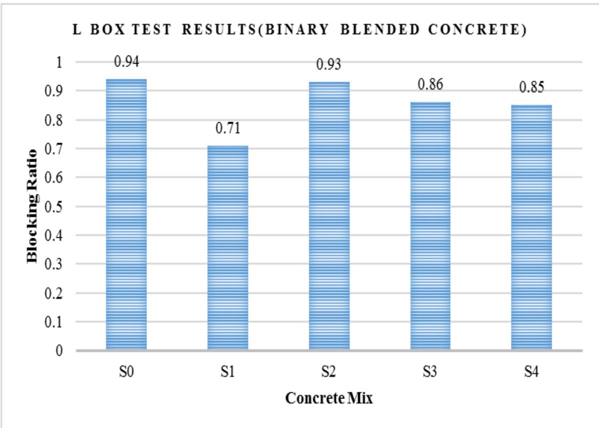
Graph 7. V Funnel Time of binary blended SCC



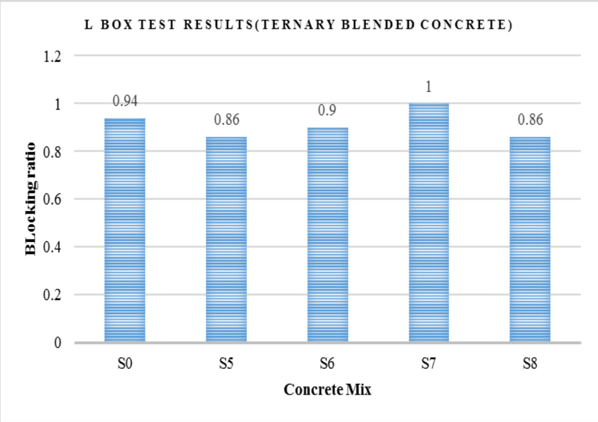
Graph 8. V Funnel Time of ternary blended SCC

Discussion: Mixes S0, S2, S4, S6, S8, even with congested reinforcement, will show good filling capacity. It can lift itself and typically has the best surface finish. Nevertheless, bleeding and racism are more likely to suffer. Mixes S1, S3, S5 and S7 with increased flow time are likely to have thixotropic effects, which can be useful in reducing the formwork pressure**[14],[15]**.

4.1.5 L box test results (Passing Ability)



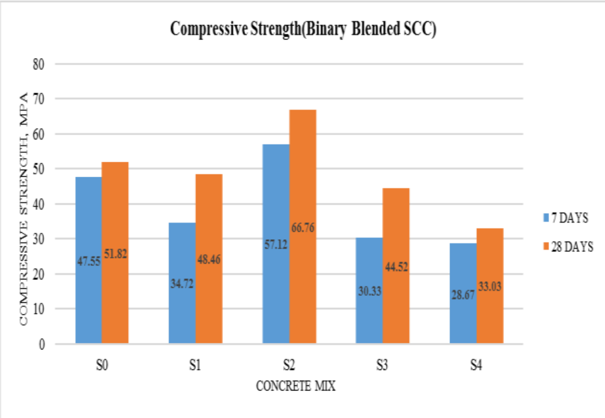
Graph 9. L Box Blocking Ratio of binary blended SCC



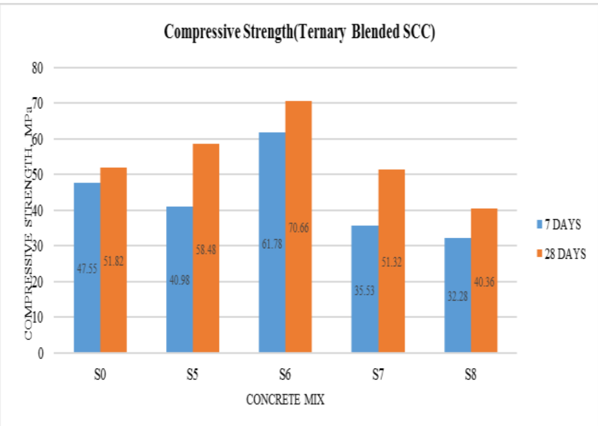
Graph 10. L Box Blocking Ratio of ternary blended SCC

Discussion: All the mixes satisfied the passing ability characteristics in L box test (Blocking Ratio>=0.8).

4.2 Compressive Strength of concrete



Graph 11. Compressive strength of binary blended SCC

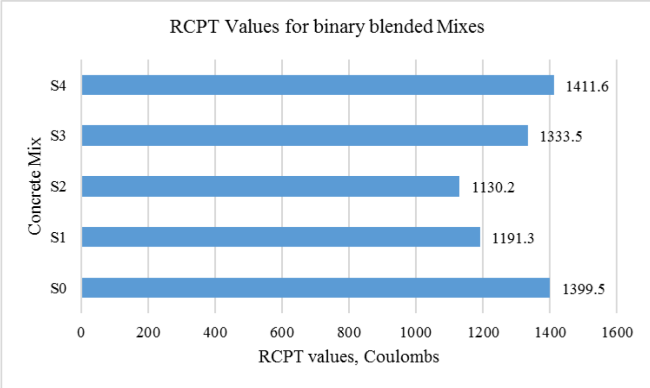


Graph 12. Compressive strength of ternary blended SCC

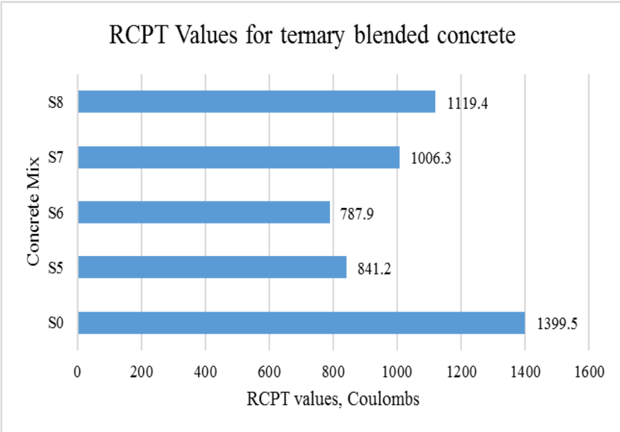
Discussion: Mix S2 gains highest strength at 28 days as the concrete becomes more compact due to finer particle size of GGBS. However S4 does not gain enough strength due to incomplete hydration of binder.Ternary blended mixes compensate for the loss in strength as Alccofine contributes for the strength gain.

4.3 Durability test results of concrete

4.3.1 RCPT test results

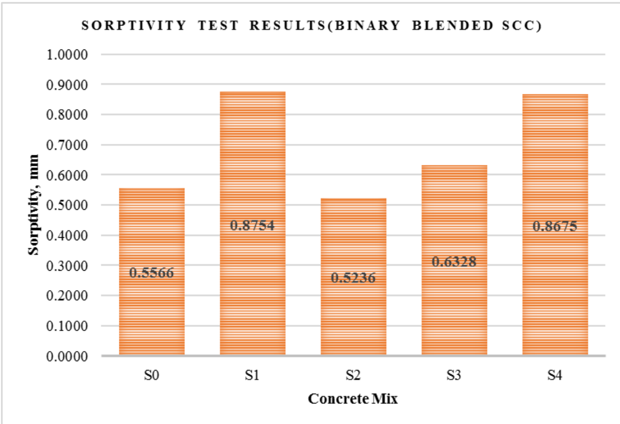


Graph 13. RCPT values of binary blended concrete

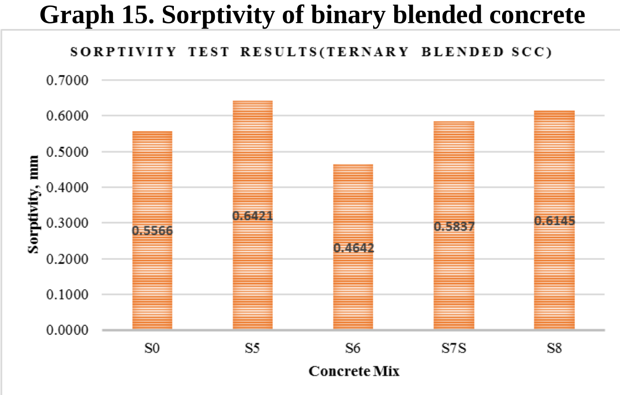


Graph 14. RCPT values of ternary blended concrete

4.3.2 Sorptivity of concrete



Graph 15. Sorptivity of binary blended concrete



Graph 16. Sorptivity of ternary blended concrete

Discussion: Mix S2 and S6 exhibit lowest sorptivity among binary and ternary blended concretes.

V. CONCLUSION

- Binary blended mixes at all replacement levels of OPC with GGBFS(30%,40%,50%, 60%) satisfy the requirement for all normal applications as per EFNARC guidelines with respect to slump flow.
- Ternary blended mixes with Alccofine also possess higher flow values as the Alccofine used is only 5% of binder. Though higher percentage of Alccofine result higher strength values but will result in lower flow of concrete and also makes the concrete uneconomical due to higher cost compared to OPC.
- Cube strength of binary blended concrete will increase with replacement of GGBS with OPC till 40%. But higher replacement of OPC with GGBFS will result in unsatisfactory strength of concrete due to the incomplete hydration of GGBFS. However higher strength will be observed in concrete with higher GGBFS at a later stage.
- Usage of Alccofine induces early strength gain of concrete.
- Binary and ternary mixtures show lower resistance to chlo ride ion penetration in comparison with OPC concrete. Chloride ion penetration increases at replacemen t levels above 40 percent of OPC due to incomplete binder hydration.
- Sorptivity of binary and ternary blended mixes decrease upto 40% GGBFS and increase thereafter.

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AUTHORS PROFILE

Prof. Abdul Razak B .H., currently pusuing Ph.D in Visvesvaraya Technological University in the field of construction materials. His fields of expertise include alternative building materials, artificial intelligence and concrete technology. The author has guided several under graduate projects in the field of Civil Engineering. He has more than 8 years of teaching and research experience. The author is working as Assistant Professor at department of civil engineering, JSS Academy of Technical Education, Bangalore, Karnataka, India. He has published several technical papers in the reputed journals and also authored handbooks in Civil Engineering. He is a life member of Indian Concrete Institute (ICI-KBC).

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