LIGHT WEIGHT CONCRETE (PARTIAL REPLACEMENT OF COARSE AGGREGATE USING POLYSTYRENE BEADS)

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ABSTRACT: The project reports the result of light weight concrete (partial replacement of coarse aggregate usingpolystyrene beads) .With increase in demand for construction materials, man has improved a lot in construction techniques of structure.In old ages structures were constructed with heavy materials but in the modern age of construction old techniques are being more costly due to heavy loading.so the use of lightweight materials are startedto reduce the cost and weight of structures. Now, a days coarse aggregate is replaced by polystyrene beads either partially,or fully depend upon the requirement of the work or structure. The characteristics of new lightweight concrete consisting of polystyrene, sand, cement, coarse aggregate and water. This work shows the results of an experimental study on various workability and durability tests on concrete containing Polystyrene as a replacement of coarse aggregate such as compressive test, split tensile test and flexural strength. For this research work M20 grade is used and the tests are conducted for various proportions of Polystyrene with coarse aggregate 5%,10%,15%,20%, 25%.The obtained results were compared with those of conventional concrete. The results showed that the amount of polystyrene beads incorporated in concrete influences the properties of hardened concrete. At 28 days, it was found that compressive strength of 5%, 10%, 15%, 20%. and 25% EPS incorporated concrete strengths were 91%, 77 %, 71%, 63%, and 57%, respectively when compared to concrete with no EPS case. The usage of partial replacement of coarse aggregate using polystyrene beads in concrete gives prospective solution to the construction industry. Polystyrene beads are the waste material obtained from packaging industries. This paper handles the partial replacement of coarse aggregate in concrete by polystyrene beads.

I. INTRODUCTION

GENERAL

Increase in the developmental activities world over, the demand for construction materials is increasing continuously. This trend will have certainly greater impact on the economic system of any country. India is also aiming at a high developmental rate compared to other nations in Asia. There is heavy demand for the building materials in the domestic market, which is becoming scarce day by day. At this point researchers and engineers who have the foresight to keep the developmental activities abreast and curtail the cost factor should look out for other alternative building materials.

TYPES OF LIGHTWEIGHT CONCRETE.

Lightweight concrete can be prepared either by injecting air in its composition or it can be achieved by omitting the finer sizes of the aggregate or even replacing them by a hollow, cellular or porous aggregate. Particularly, lightweight concrete can be categorized into three groups:

- No-fines concrete.
- Lightweight aggregate concrete.
- Aerated/Foamed concrete.

NO-FINES CONCRETE.

No-fines concrete can be defined as a lightweight concrete composed of cement and Coarse aggregate. Uniformly distributed voids are formed throughout its mass. The main characteristics of this type of lightweight concrete is it maintains its large voids and not forming laitance layers or cement film when placed on the wall.

No-fines concrete usually used for both load bearing and non-load bearing for external walls and partitions. The strength of no-fines concrete increases as the cement content is increased. However, it is sensitive to the water composition. Insufficient water can cause lack of cohesion between the particles and therefore, subsequent loss in strength of the concrete. Likewise too much water can cause cement film to run off the aggregate to form laitance layers, leaving the bulk of the concrete deficient in cement and thus weakens the strength.

LIGHTWEIGHT AGGREGATE CONCRETE

Porous lightweight aggregate of low specific gravity is used in this lightweight concrete instead of ordinary concrete. The lightweight aggregate can be natural aggregate such as pumice, scoria and all of those of volcanic origin and the artificial aggregate such as expanded blast-furnace slag, vermiculite and clinker aggregate. The main characteristic of this lightweight aggregate is its high porosity which results in a low specific gravity. The lightweight aggregate concrete can be divided into two types according to its application. One is partially compacted lightweight aggregate concrete and the other is the structural lightweight aggregate concrete. The partially compacted lightweight aggregate concrete is mainly used for two purposes that is for precast concrete blocks or panels and cast in-situ roofs and walls. The main requirement for this type of concrete is that it should have adequate strength and a low density to obtain the best thermal insulation and a low drying shrinkage to avoid cracking . Structurally lightweight aggregate concrete is fully compacted similar to that of the normal reinforced concrete of dense aggregate. It can be used with steel reinforcement as

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to have a good bond between the steel and the concrete. The concrete should provide adequate protection against the corrosion of the steel. The shape and the texture of the aggregate particles and the coarse nature of the fine aggregate tend to produce harsh concrete mixes. Only the denser varieties of lightweight aggregate are suitable for use in structural concrete.

AERATED CONCRETE

Aerated concrete does not contain coarse aggregate, and can be regarded as an aerated mortar. Typically, aerated concrete is made by introducing air or other gas into a cement slurry and fine sand. In commercial practice, the sand is replaced by pulverized-fuel ash or other siliceous material, and lime maybe used instead of cement .

There are two methods to prepare the aerated concrete. The first method is to inject the gas into the mixing during its plastic condition by means of a chemical reaction. The second method, air is introduced either by mixing-in stable foam or by whipping-in air, using an air-entraining agent. The first method is usually used in precast concrete factories where the precast units are subsequently autoclaved in order to produce concrete with a reasonable high strength and low drying shrinkage. The second method is mainly used for in-situ concrete, suitable for insulation roof screeds or pipe laggin.

In this project, an attempt is made to address the possibility of utilizing Expanded Polystyrene (EPS), a packing material in the form of beads in concrete, which otherwise is posing a threat to waste disposal as well as for waste management. This material is a cause of concern to environmentalists. In this project, it is attempted to partially replace coarse aggregates by means of EPS beads.

Expanded polystyrene (EPS) is a lightweight cellular plastics material consisting of fine spherical shaped particles which are comprised of about 98% air and 2% polystyrene.It has a closed cell structure and cannot absorb water. It has a good sound and thermal insulation characteristics as well as impact resistance.Polystyrene foam is a non-biodegradable material. It is a waste material from packaging industry. It creates disposal problem. Utilizing crushed polystyrene granules in concrete is a valuable waste disposal method.

There are many advantages to be gained from the use of lightweight concrete.These include lighter loads during construction, reduced self-weight in structures, and increased thermal resistance. Lightweight concrete is generally accepted as concrete having a density of about 1800 kg/cu.m or less.

The present research was taken up, keeping two targets in view, disposal of the polystyrene waste from the point of view of environment and for the replacement of aggregate from the point of view of construction industry. The present project aims at utilization and the suitability of polystyrene beads as coarse aggregate. A comparative study on strength parameters is also done against conventional concrete to study the behavior of the polystyrene aggregate. For this 5%, 10%, 15%, 20% and 25% replacement of coarse aggregate by expanded polystyrene beads is attempted in this project.

II. OBJECTIVES

1). To find a concrete mix proportion which gives better results than over burnt bricks.
2). To study the properties, such as density and compressive strength of lightweight polystyrene concrete
3). EPS concrete can be used to produce low density concretes required for building applications like cladding panels, curtain walls, composite flooring system and load bearing concrete blocks.
4). Excellent thermal insulation capacity.
5). Easily controllable protection against the impact of shocks and drops.
6). Flexibility of moulding.
7). Stable in adverse weather conditions.
8). Neutral for the environment and free of CFC.

PROPERTIES

1.Polyconcrete is a concrete made from polystyrene beads particles as aggregates.
2.polystyrene concrete is a lightweight ,low strength material with good energy absorbing characteristics.

APPLICATIONS.

- Generally, it is used in combination with other materials like steel (to make sandwich panels) which usually used for cold store construction, as the expanded polystyrene is good as a thermal insulation.
- Due to its good energy absorbing characteristics, polystyrene concrete can also be used as a protective layer of a structure for impact resistance, especially for the protection of buried military structures and fenders in offshore oil platforms.
- Principally, expanded polystyrene concrete is used for prefabricated non-load bearing panels, hollow and solid block, lightweight sandwich panels.
- It can be used in highway construction as part of the sub-base where frost is harmful for sub grade stability.
- In building and construction, expanded polystyrene concrete almost can be used in any application where a combination of insulation and strength are required, such as roofs ,Cladding panels. Curtain walls and Ceiling.
- It can be used in Load-bearing concrete blocks, floating marine structures and Sub-floor systems.
- In Australia, the primary use of polystyrene aggregate concrete has been the manufacture of non-structural c(Hnponents of concrete buildings including perimeter insulation, roof insulation, and masonry insulation.

ADVANTAGES AND DISADVANTAGES.

Advantages.

- lighter weight down to 600kg/m3.
- Having strength ranging from 2 to 20 N/mm2.
- Suitable for structural and non-structural members.

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- lesser cost than any other lightweight concrete.
- Acoustic resistance among all other lightweight concrete.
- Fire resistance.
- Very workable at low water cement ratio.
- Thermal insulation best among other lightweight concrete.
- Lighter loads during construction.
- Reduction in self-weight of structures.
- Increased thermal resistance.

Disadvantages.

- Sensitive to most petroleum products.
- Not suitable to be used as prestressed concrete.
- Starts to evaporate above 300 degree celcius .
- Stable up to 30 minutes after mixing.
- It is very light which can cause segregation in mixing.
- It has hydrophobic characteristic due to which it is quite difficult to wet when
- mixing. Hence there may be a possibility of non uniform distribution.
- Shrinkage of polystyrene concrete is higher than that for normal weight
- concrete due to the low stiffness of the expanded polystyrene beads, which provide very little restraint to the shrinkage of cement paste.
- Full compaction is difficult to achieve with the expanded polystyrene mixes.

III. METHODOLOGY

MATERIALS

The raw materials used in this experimentation were locally available.and these include OPC 43 GRADE cement as binding material,river sand of zone3 as fine aggregate,EPS beads and potable tab water was used for mixing and curing throughout the entire work.

CEMENT

The cement used was ordinary Portland cement of 43- grade conforming to IS 12269. The cement should be fresh and of uniform consistency. Where there is evidence of lumps or any foreign matter in the material, it should not be used. The cement should be stored under dry conditions and for as short duration as possible.

S. No	Characteristics	Values obtained	Standard values
1.	Normal consistency	31%	33%
2.	Intinal setting time	48 min	Not less than 30 minutes
3.	Final setting time	240 min	Not be greater than 600 minutes
4.	Fineness	4.8%	<10

Physical properties of cement.

WATER

Water used in the mixing is to be fresh and free from any organic and harmful solutions which will lead to deterioration in the properties of the mortar. Salt water is not to be used. Potable water is fit for use mixing water as well as for curing of beams.

Properties	Observed values
PH	8.0
Dissolved solids, mg/l	290
Suspended solids	Nil
Chlorides,mg/l	20

Properties of Water.

FINE AGGREGATE

The aggregates having size less than 4.75mm and of zone 3.fine aggregate used for work was river sand .the sand was dried and free from any unwanted material ,before mixing.specific gravity of sand is 2.61.

S.no	Properties	Values
1	Specific gravity	2.61
2	Water absorption	2%
3	Fineness modulus	3.43
4	Bulk density	1650kg/m3

properties of sand

S.NO	IS sieve designation	Zone 1 grading	Zone 2 grading	Zone 3 grading	Zone 4 Grading
1	10mm	100	100	100	100
2	4.75mm	90-100	90-100	90-100	90-100
3	2.36mm	60-95	75-100	85-100	95-100
4	1.18mm	30-70	55-90	75-100	95-100
5	600μ	15-34	35-59	60-79	80-100
6	300μ	5-20	8-30	12-40	15-50
7	150μ	0-10	0-10	0-10	0-15

Limits for fine aggregates as defined in IS: 2386 (Part I)-1963.

IS sieve size	Weight Retained Grams	Cummilative Weight retained in grams	Cummilative % weight retained	Passing %
4.75mm	66.00	66.00	6.60	93.40
2.36mm	165.00	231.00	23.10	76.90
1.18mm	270.00	501.00	50.10	49.90
600μ	108.00	609.00	60.90	39.10
300μ	254.00	863.00	86.30	13.70
150μ	91.00	954.00	95.40	4.60
75μ	18.00	972.00	97.20	2.80
Sum	972.00		∑F=322.40	

sieve analysics of fine aggregate

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Fineness modulus of fine aggregate=∑F/100
=322.40/100
=3.2

COARSE AGGREGATE.
The aggregates having size more than 4.75 mm are called as coarse aggregate. Locally available crushed stone is used as coarse aggregate. Size of aggregates are 10mm and 20mm .The properties and sieve analysis of 10 mm and 20mm nominal sized aggregates are presented in table.

S.no	Properties	Values
1	Type	Crushed
2	Water absorption	About 0.9%
3	Fineness modulus	6.4
4	Nominal size	10mm
	Specific gravity	2.75

Properties of 10 mm Coarse aggregates.

IS sieve size	Weight Retained in Grams	Cummilative Weight retained in grams	Cummilative % weight retained	Passing %
20mm	15.00	15.00	0.50	99.50
16mm	31.00	46.00	1.53	98.47
12.5mm	208.00	254.00	8.47	91.53
10mm	731.00	985.00	32.83	67.17
4.75mm	2015.00	3000.00	100.00	0.00
Sum	3000.00		∑C=143.33	

sieve analysics of 10mm coarse aggregate.

Fineness modulus of 10mm coarse aggregate=∑C+500/100
=143.33+500/100
=6.4

S.no	Properties	Values
1	Type	Crushed
2	Water absorption	About 0.6%
3	Fineness modulus	7.71
4	Nominal size	20mm
	Specific gravity	2.75

Properties of 20 mm Coarse aggregates

IS sieve size	Weight Retained in Grams	Cummilative Weight retained in grams	Cummilative % weight retained	Passing %
40mm	0.00	0.00	0.00	100.00
20mm	93.00	15.00	3.10	96.90
16mm	183.00	276.00	9.20	90.80
12.5mm	267.00	543.00	18.10	81.90
10mm	2058.00	2601.00	86.70	13.30
4.75mm	399.00	3000.00	100.00	0.00
Sum	3000.00		∑C=217.10	

sieve analysics of 20mm coarse aggregate.

Fineness modulus of 10mm coarse aggregate=∑C+500/100
=217.10+500/100
=7.1

IV. POLYSTYRENE AGGREGATES.
The aggregate is made from raw polystyrene,which consists of spherical beads containing an expanding agent.when the glossy beads are heated by live steam they soften and expand,forming a cellular structure.this process is best carried out when the aggregate is required.the density of polystyrene beads is near about 16-27 kg/m3.Before polystyrene beads can be used as aggregate they must be left for more than four hours to take up air.the beads are inelastic ,and do not recover when deformed ,yet they are able to withstand the stresses when the concrete is mixed and compacted.Polystyrene beads are non-absorbent,since their cells are closed.their primary function is to act as a filte in the concrete mix.however the high thermal resistivity of the concrete and some of its desirable properties result from the presence of the beads.Polystyrene has so many commercial names such as “styropor”and “karkal”.it is used mainly as insulating material,and is manufactured in particles of small diameters up to 4mm.the beads used in this work of diameter range of 1.118 to 2.40 mm.

S.No.	Particulars	Value
1	Apparence	White emulsion
2	Freeze/thaw resistance	Excellent
3	Flammability	Non-flammable
4	Density	13kg/m3
5	Compressive strength	0.09Mpa

Properties of EPS Beads

MIX DESIGN
Polyconcrete is made by mixing the lightweight aggregate (expanded polystyrene breads) with cement, sand and water in a conventional mixer.its density can be adjusted withn close limits to anywhere in the range 500-2000 kg/m3,so that it can be used for insulating screeds and rendering, non-bearing and load bearing components. Within the normal density range of non-structural lightweight concretethe uniformly dispersed expanded polystyrene breads occupy much of the volume between 600 kg/m3 and 800 kg/m3, where compressed aggregate occupies 60-80%, nearly all the remaining space being filled by the mortar.since the mortar determines the mechanical propertiesof the material it generally has high cement content.the consistency of fresh polyconcrete is not adequatelymeasured by means of test generally employed for normal concrete,e.g various forms of slump tests.the compacting factor test can be applied as a measure of consistency and workability, bt the values obtained need to be interpreted differently from the values of normal concrete.the difference arises from the high proportion of the very regular aggregate,which gives a mix which is lean and not very cohesive, but offers little resistance to flow.

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W/C =0.50

S.NO	SPECIMEN	EPS (%)	WATER (kgs)	CEMENT (kgs)	FINE AGG (kgs)	COARSE AGG 20MM (kgs)	COARSE AGG 10MM (kgs)	EPS (kgs)
1	EPS0	0	145	290	696	1029	400	0
2	EPS5	5	145 0	290	696	977.55	380	71.45
3	EPS10	10	145	290	696	926.10	360	142.90
4	EPS15	15	145	290	696	874.61	340	214.39
5	EPS20	20	145	290	696	832.20	320	285.80
6	EPS25	25	145	290	696	771.75	300	357.25

Mix Design

V. EXPERIMENTAL ANALYSIS

PROCEDURE

BATCHING AND MIXING

Weigh batching was practiced with the help of electronic weigh balance. Batching was done as per mix proportion. The mix was prepared manually. First all three dry materials cement, sand and coarse aggregate mixed dry through, then properly mix these three ingredients by adding water after that mix all by adding EPS beads it makes uniform mixture.

PLACING AND COMPACTING.

Moulds are cleaned and oiled to prevent the formation of bond between concrete and moulds. The fresh concrete filled into the moulds in three layers with hand compaction at least of 25 blows after adding each successive layer. The entrapped air in concrete is removed by table vibrator. In case of concrete with EPS beads vibration makes the segregation. Vibrations are given as there no segregation was occur and EPS beads does not float on concrete, So give more preference to hand compaction method for concrete containing EPS beads. After the compaction has been completed, the excess mortar was removed from the mould with the help of trowel and the surface was levelled.

DEMOULDING AND CURING

After placing fresh concrete in moulds, it was allowed to set for 24 hours. Concrete samples were demoulded and it was marked with some permanent identification mark. Concrete samples now kept in curing tank for required time span of 7days, 14 days and 28 days, after that time span, concrete samples were removed from curing tank to conduct tests on hardened concret

TEST ON FRESH CONCRETE

SLUMP TEST: In general, it was observed that workability of a concrete mix increased on addition of polystyrene. Workability of the mixes was observed to increase with increase in percentage replacement of coarse aggregate with polystyrene (as a partial replacement of aggregate) i.e., higher the polystyrene replacement, higher was the workability.

Concrete mix	Slump value (mm)
Concrete mix M20 grade	60
5% replacement	65
10% replacement	68
15% replacement	70
20% replacement	75
25% replacement	81

Slump value for different percentage of polystyrene beads.

COMPACTION FACTOR TEST : Compaction factor test is another method used for find out the workability of the fresh concrete. It is more accurate than slump test.From the values obtained it is clear that workability of concrete increases with percentage of polystyrene increases.

Concrete mix	Compaction factor
Concrete mx M20 grade	0.876
5% replacement	0.899
10% replacement	0.910
15% replacement	0.925
20% replacement	0.943
25% replacement	0.949

Compaction factor values for different percentage of polystyrene beads.

VI. RESULTS AND DISCUSSION

Weight of specimen for a standard cube of 150mm X 150mm X 150mm is measured for all the mixes of concrete. The results are tabulated in table below.

Mix	Composition of Polystyrene	Weight of specimen(KG)
Standard	0%	8.415
A	5%	8.110
B		

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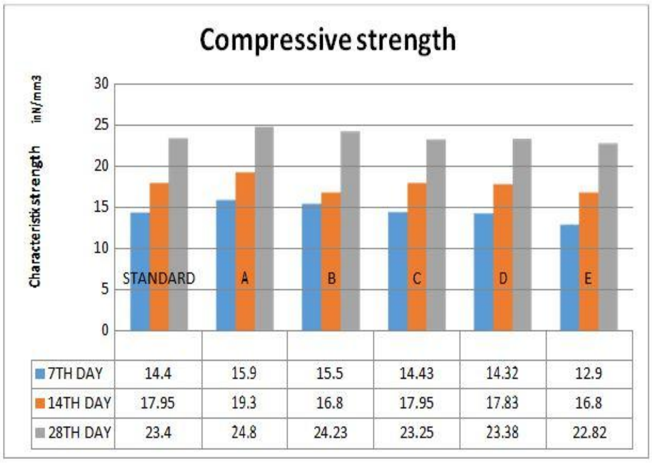
	10%	7.850
C	15%	7.760
D	20%	7.550
E	25%	7.465

Weight of different specimen

COMPRESSIVE STRENGTH TEST: Compressive strengths of control concrete (Standard), A(5%), B(10%), C(15%), D(20%), E(25%)of polystyrene imparted specimens respectively for 7,14 and 28 days curing are shown.



Average compressive strength

DISCUSSION ABOUT THECOMPRESSIVE STRENGTH TEST.

RESULTS:

While considering figure 2, the compressive stress is plotted for all the concrete mixes (Standard mix- control concrete, A-5%, B – 10%, C- 15%, D- 20%, E – 25%)with the replacement of coarse aggregate. Here it is seen that, the compressive strength of mix „A" (5% replace) shows strength much higher than the controlled concrete, in 7th, 14th and 28th day tests. Same scenario is seen in other few mixes B– 10%, C- 15%, D- 20%. Strength varies in percentage with control concrete. A has 10.24% strength more than controlled concrete, like wise B,C, D has strength 9.21%, 7.17%, 2.05% more than controlled concrete, respectively. Mix E with 25% replace has a strength of 22.82N/mm2, which is 2.05% less than the controlled concrete.

COST ANALYSIS

EPS CONCRETE PER CUBIC METRE

Material	Quantity	Rate	per	Amount(Rs)
CEMENT	290	5	kg	1450
WATER	145	0.10	litre	14.5
COARSE AGGREGATE	1429	3	kg	4287
FINE AGGREGATE	696	1.25	kg	870
EPS BEADS	51	20	Kg	1020
TOTAL AMOUNT				7641

Cost analysics of EPS concrete cube.

NORMAL CONCRETE PER CUBIC METRE

Material	Quantity	Rate	Per	Amount(Rs)
CEMENT	290	5	kg	1450
WATER	145	0.10	litre	14.5
COARSE AGGREGATE	1429	4	kg	5716
FINE AGGREGATE	696	1.25	kg	870
TOTAL AMOUNT				8050.5

cost of normal concrete cube.

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VII. CONCLUSION

Polystyrene concrete can be classified as lightweight concrete according to American Concrete Institute (ACI). It is because the density of polystyrene concrete is in the range set by ACI which is 300 to 1850 kg/m3.

The workability characteristics of the mixes are very different from the normal concrete. Compaction by vibration was not effective owing to the lightweight nature of the mixes. The mixes were cohesive that the cement slurry coating the beads was very effective in holding the mix together.

EPS contribute to low weight and low density; it also contributes to the low strength of the specimens. EPS do not contribute to the strength of the material. The strength obtained in the mixes with EPS is very low, due to the bead's weakness in compression. This is also because EPS do not react chemically with the mix to contribute strength.

The arch rise of an arch tile affects its behavior under load application. Comprehensively, under a fixed measurable span length, and thickness; an arch structure with lower arch rise dimension possesses higher load bearing capacity.

The following conclusions are drawn based on the findings of the tests reported here: Compared to the control mix, the polystyrene based concrete showed a decrease in the density up to 10%.The highest strength obtained was 25.04 MPa (Mix A 5% replacement) and the corresponding strength for control concrete was

56Mpa. With consideration of flexural and tensile strength, MixB(10% replacement) has their maximum values 4.85 MPa and 3.61MPa then the control concrete 4.76 MPa, 3.56 MPa. Though Mix A has the maximum strength, their flexural and tensile strengths are less then Mix B. The strength of mix B is

89MPa, which is still higher than control concrete (23.56 MPa.), ant the weight of mix B cube is 7.958kg (Avg).

With reference to the above discussed points, mix B (with 10% replacement), is considered to be good for compressive, tensile and flexural strengths with density 5.43% less than the actual concrete.

With increase in the amount of EPS in concrete blocks, the cost reduces but also the compressive strength and tensile strength decreases gradually.

Addition of plastic beads in concrete blocks along with EPS increases the compressive strength but also increases the cost gradually.

Use of EPS and plastic beads in sensible quantity results in good compressive strength as well as increase in cost is not major.

It can serve as a way of effective use of EPS disposal as well effective use of plastic beads that are waste products of many industries

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