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Original Article

Comparative Study of Plastic Sand Block Containing LDPE with Conventional Concrete

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Abstract *- The durability of plastics, as well as their very stable molecular configuration, has posed a threat to mankind and nature since its invention. Getting these plastics recycled turns the garbage into gold. A well-designed, heavy-duty, durable plastic block thus comes to the rescue. However, as a result of less attention given to this field, the manufacturers have yet to come up with a plastic sand block that can be efficiently and effectively used in the housing industry. The said block will not only help reuse discarded plastics in a way that keeps them away from landfill sites for a considerable period of time but will also help minimize the carbon footprint level of the concrete industry.in addition to that, as a result of the universal availability of sand, the blocks thus curated will also be affordable and can be used globally. In this particular study, plastic sand blocks were forged in different ratios, and different kinds of strength tests were performed on them to check for their suitability in the housing industry. An optimum range of 65% to 85% of plastic content was deduced towards the later stage of the experiment, within which the said blocks showcased significantly high compressive strength in comparison to regular concrete with no sign of cracks or disintegration for a very considerable displacement value. This invariably results in a block wherein no compromise needs to be made with strength or workability to achieve a better, more suitable and eco-friendly alternative to concrete.*

Keywords *- Plastic sand block, Compressive strength, Affordable housing, Easy assembly, Concrete alternative.*

1. Introduction

With the ongoing rise of global pollution, there comes a pressing need to bring down the carbon emission levels that invariably lead to ecological damage over time. The construction industry is one sector that contributes significantly to such emissions. The use of sustainable materials, on the other hand, helps buildings last longer while being kind to the environment. Such substances promote higher living and running situations similar to supporting the surroundings by decreasing waste and carbon emissions. However, in due course of time, with the advancement of technology, sustainable structures took a backfoot as people started to experiment with commodities artificially curated in laboratories with the hope of getting better results, leading to the rise of concrete and its forms.

Typically, concrete comprises three constituent ingredients, namely cement, aggregates (Mix of fine aggregates, i.e. sand and coarse aggregates) and water. Cement serves as the binding constituent in such a case. In due course of time, with the progress of studies being conducted on cement, the same was found to be a boon and bane to mankind. The manufacturing process of cement has been found to be an energy-intensive process that leads to significant carbon emission levels. 1MT of cement produced is found to emit 0.8 tonnes of CO_2 [1]. 39% of the world's carbon emissions are caused by building construction [2]. In addition to that, cement dust has also been related to the rise of various autoimmune lung and skin diseases and cancers, exposing site workers to multi-fold generational ailments. Another major drawback of concrete and/or mortar is that it disintegrates over time as a result of various man-made or natural phenomena, be it floods, earthquakes, tremors caused as a result of mining activities, moving vehicles redeeming into rubbish and simultaneously causing high grades of air as well as water pollution. Furthermore, concrete structures, no matter how well-built, are always at risk of collapsing during earthquakes. This invariably calls for an alternate material that shows negligible cracking even under absurdly high displacement values.

Plastic, which was considered to be a boon to mankind in its early days, enhanced lifestyles and revolutionized medicines but eventually became an inescapable turmoil. Every arena of life, be it food, agriculture, or all other utilitarian products, has become heavily dependent on plastic in one way or the other. Products made of plastic were not only affordable but were also highly rated when it came to efficiency. Eventually, after slowly but steadily penetrating every possible industry, mankind was struck with one daunting realization. The plastics so formed, due to their very stable molecular arrangement, take hundreds of years to disintegrate, which by the end of the 20^{th} century, merely 60 years post its invention, were already seen to cause great havoc in every nook and corner. From the peak of Mount Everest [3] to the bottom of seas and oceans [4], plastic pollutants were seen to be scattered everywhere. As per the reports of the Trade Association Plastics Europe, worldwide plastic production grew from 1.5 million metric tons per year in 1950 to an estimated 275 million metric tons by 2010, which surged to 359 million metric tons by 2018 [5].

The sustainability involved with waste management accounts for a better decision-making process and supportive policies together with appropriate treatment technologies, reusing of ideal waste, and methods of resource recovery, thereby reaching the objectives of sustainable development. Sustainable development ensures greater protection of the environment along with better preservation of natural resources, thus greater capacity to meet the demands of future generations, in addition to the present needs. As such, it becomes imperative to develop strategies with industrial, agricultural and technological policies so as to establish the basis of sustainable development.

Several types of plastics can be utilized in the construction industry and have a high recycling potential. A study by Awoyera and Adesina [6] indicated that depending on the type and properties of the plastic waste, they may have potential use in various applications after recycling.

High-Density Polyethylene (HDPE) is a relatively hard and rigid material that can be applied in the manufacture of plastic tables, chairs, lumber, and other furniture. Likewise, as Light-Density Polyethylene (LDPE) is flexible, it can potentially be used in the production of blocks and bricks. Polypropylene (PP) is hard and flexible, and as such, it can be used as aggregates in asphalt mixtures. Polystyrene (PS), in its rigid form, is hard and brittle, which makes it ideal for uses where mechanical stress is minimal, such as in insulation materials. In contrast, PVC, another type of plastic, is both hard and rigid. This characteristic suggests its potential as an aggregate in cement-based materials. PET, on the other hand, happens to be hard and flexible, and the most common secondary application is in the form of fibres in cementitious composites. Table 1 shows the various factors that must be assessed when incorporating plastic waste in concrete mixes.

Its recycling and reuse can strategically tackle growing amounts of plastic waste in our ecosystem in an effective manner. As a low-cost alternative, waste plastics can be brought back to life in ways that can specifically reduce the consumption of natural resources and protect the environment while keeping in mind that factors such as efficiency, durability, and sustainability are all taken into consideration. Not only as partitions or decoratives, discarded plastics can also very well be used as one of the principal components in the case of load-bearing structures.

1.1. Research Gap

Experiments conducted so far focus solely on improving strength parameters when it comes to road construction, pavements or footpaths. The bituminous mix in such cases contains a small percentage of shredded plastic, which, in most cases, has led to an appreciable increase in road sturdiness. However, no significant research has been done when it comes to building structures with different load parameters. In this particular paper, an attempt has thus been made to bring forth a plastic block that can be utilized for constructing residential as well as commercial structures.

Table 1. Factors to be assessed and tests to be done to check plastic compatibility for concrete mixes. [7, 8]

Test	Factors to be considered	Possible contribution to strength development
Slump Test	W/C ratio, Substitution level of PA and PF, Shape of PA (plastic aggregate) or PF (plastic fibre)	Generally, increasing the amount of PA/PF would reduce the slump value due to the non-uniform shape of PA/PF and low fluidity absorption capacity.
Unit weight and Density	Amount of PA or PF Shape of PA or PF	An increased level of substitution reduces the density of PA. Using PF, little changes of density.
Air Content	Amount of air content	The incorporation of PA and PF increases the air content as plastic and natural aggregates cannot bind together, thereby increasing porosity.
Compressive strength test	W/C ratio, Substitution level of PA and PF, Shape of PA or PF, Ratio and Geometry of fibres	Increasing the W/C ratio or substitution level of PA or PF led to a reduction in compressive strength due to low elastic modulus and low bond strength between the surface of plastic and aggregate.
Splitting Tensile Strength	Substitution level of PA or PF	Increasing the PA (PET) substitution level would decrease the tensile strength. However, increasing the PF substitution level would increase the tensile strength.
Elastic Modulus (E_c)	Substitution level of PA or PF, Shape of PA or PF, Type of waste plastic, Porosity of aggregates	The E_c of PA concrete is much lower than that of conventional concrete with the same W/C. Significantly lower Ec can be observed if the shape of PA becomes irregular. In the case of PF, not much difference in E_c as in conventional concrete.

2. Literature Review

In due course of time, experiments were conducted with regard to plastic incorporation in bituminous mixes as well as concrete. This has led to the rise of different types of construction mixes that utilize plastic efficiently. Several studies have been conducted describing the various aspects of the utilization of plastic waste in the construction of roads. A study was done [9] involving the manufacture of bricks or building blocks from sand and waste plastics. The blocks were forged by combing discarded plastic and sand after heating at 200˚C. Two kinds of bricks were developed for the purpose, one comprising sand and waste CDs and another comprising sand and wastewater bottles, which were produced and tested for some physical and mechanical properties. The sand-plastic bricks turned out to be lightweight and had a waxy surface. It was observed that sand plastic bricks have low water absorption (Plastic Bricks: 6.5%, CD bricks: 4.5%, Normal Bricks: 9.42%), low apparent porosity (Plastic Bricks: 12.04%, CD Bricks: 7.98%, Normal Bricks: 22.24%) and higher compressive strength (Plastic Bricks: 10.6 MPa, CD Bricks: 10 MPa, Normal Bricks: 1.77 MPa). In [10], the focus is on flexible road pavements, where various tests—including the Stripping Test, Marshall Stability Test, and Water Absorption Test—were performed on bituminous mixes with plastic waste-coated aggregates.

The results indicated that, at an optimal percentage of plastic incorporation, the test values significantly surpassed those of ordinary bitumen. In addition to that, the roads do not suffer the adverse effects of UV radiation, leading to a significant drop in the maintenance cost as well. In 2019 [11], a research work dealt with the effects of using LDPE plastic waste powder as a replacement for cement in percentages 0, 10, 20, and 30. A total of 36 cube specimens were cast, cured, and tested for compression strength at 7, 14, and 28 days. PVC was powdered to a fine powder and mixed with sand and cement uniformly, followed by incorporating coarse aggregates of size 10mm. The experimental study concluded that 10% replacement of cement with PVC plastic is applicable. In another study conducted to estimate the optimum dosage of LDPE grade plastic in the Bituminous mix for highway road construction, different tests like those of Ductility, Penetration, Softening Point, Specific Gravity, Flash and Fire Point as well as Marshall's Stability test were conducted [12]. According to the results, the optimal binder content for the Dense Bituminous Concrete (DBC) mix using 80/100-grade bitumen was 5.5%, which achieved the highest Marshall stability value of 905 kg.

DBC prepared incorporating LDPE showed a significant increase in the stability value at an optimum mix of 4% LDPE in the bituminous mix. It was also seen that with an increase in the mix percentage, there was a significant reduction in air voids. Another study [13] involved three types of nine paver blocks of size 200 x 100 x 75 mm, comprising LDPE waste in different proportions with sand and coarse aggregate. The plastic bag used is about 50 microns, which is melted at 160˚C. Three different mixes of Plastic, Sand, and Aggregate were prepared in the following ratios: 1:1:1, 1:1.5:1.5, and 1:2:2. Test results showed that the compressive strength of plastic paver block is found to be 10.43% more than concrete paver block for ratio 1:1.5:1.5 which can be used in non-traffic and light traffic road, gardens, pedestrian path etc.

In addition, it requires less time to manufacture these blocks. The weight of these blocks was also found to be up to 15% less. The authors, in yet another paper [14], put forward various types of plastic waste that can be used as a binding material to replace cement and produce cement-less paver blocks completely. The paver block is made from a blend of various types of plastic waste mixed with natural fine aggregate in different proportions. LDPE waste was used to replace cement in proportions of 40%, 50%, 60%, and 70%. As per the test results, the plastic paver block has shown a low water absorption potential with an average initial and final setting time of 19 and 24 minutes, respectively. The abrasion test indicated low surface wear, thereby promising higher durability with a maximum of 2.56% wear. Table 2 puts forward a comparative study of the various kinds of blocks infused with plastic.

There are, however, two major drawbacks. Firstly, the usage of plastic has been limited to a very specific grade of plastic. Secondly, there has been no improvement in the CO_2 emission levels. As such, experiments performed led to a different type of plastic sand brick being used for road construction, wherein the percentage of plastic incorporated was significantly higher than that of previous mixes.

In this particular research, experiments were conducted to fabricate a plastic sand block that can be utilized in the housing sector as a replacement for concrete. The percentage of plastic incorporated ranged from 50% to 90% by volume. Different grades of sand, varying from very fine to coarse sand, were also utilized. Once the blocks were made, a number of parametric tests were conducted to identify the strength parameters of the blocks that were thus fabricated.

3. Materials and Methodology

3.1. Sand

The sand utilized here gives mass to the blocks designed. Sieve analysis was on the sand obtained to classify them into different groups based on their sizes. This was done with the intent of discerning which particle size was best suited to devise the plastic sand blocks. The different grades of sand were mixed with LDPE granules subsequently to form the plastic sand blocks. Each grade of sand is seen to give a different compressive strength value as a result of air void formation, as the mixing done in this experiment has been entirely manual. The purpose of manual mixing was to ascertain if such blocks could be produced comfortably in places that lack machine accessibility and skilled labourers.

Table 2. Table showcasing a comparative study of the various kinds of plastic blocks [15, 16, 17]

Sl. No.	Process Involved	Max. Plastic Content	Strength Obtained
1	Melting -> Cooling-> Crushing (20 mm aggregate Size) (Plastic is used as a Coarse Aggregate replacement) [11]	20%	Comparable with conventional concrete
2	Plastic (PET) here is used as a binding material, that is, as a cement replacement. [12]	30% PET	52 N/mm^2
3	Plastic is used as a partial replacement of fine aggregate checked for M20 Grade [5]	4%	70 N/mm^2
4	Polyethylene Plastic is used as a partial replacement for fine aggregate. Polyethylene waste is cut into small pieces and ground into fine particles, followed by mixing with Portland Cement and Water [13]	5%	1520 N (Crushing Strength after 28 days)
5	An attempt was made to incorporate waste plastics in structural bricks. Two variants were developed by heating the plastic waste with sand at 200˚C. Type 1: Sand + Waste CDs, Type 2: Sand + Plastic Water Bottles [14]	–	10 MPa and 10.6 MPa respectively.
6	Five blocks were prepared in five different ratios of Sand, Plastic Waste, Nylon Grid as Type 1: 1:0.14:0.05, Type 2: 1:0.23:0.08, Type 3: 1:0.28:0.1, TYPE 4: 1.25:0.3:0.13, Type 5: 1.15 :0.34: 0.15 and tested [15]	–	Type 3: 8.19 MPa Type 4: 8.8 MPa Type 5: 8.2 MPa
7	Plastic Waste is used as a binder. The waste plastic is first burnt in a closed chamber and melted to a liquid state, followed by its mixing with other ingredients [16]	–	16.05 N/mm^2)
8	PVC plastic waste, powdered to a fine powder, is used as a partial replacement of cement and mixed with sand cement and coarse aggregate of size 10 mm [17]	10%	Comparable with conventional concrete pavers
9	Waste plastic as partial replacement of FA for M30 concrete. [18]	10%	54 N/mm^2
10	Polythene bags are used as a fine binding material. At first, the polythene bags are heated to 105-115˚C, followed by mixing with M-sand until a binding consistency is achieved. The mix is then mixed with OPC in the ratio 1:4 (plastic mix: cement) [19]	–	Significantly higher than the conventional blocks.

Table 3 puts forward the various properties of FA, in this case, sand, that make it suitable for usage in the housing blocks.

Table 3. Properties of FA/ Sand [18]

Property	Description
Particle Size distribution	Ensures good packing, reduces void and improves workability.
Shape and Texture	Angular and rough texture enhances bonding
Durability	Withstands weathering, chemical attacks, etc.
Impact Resistance	Can endure dynamic load or shocks

3.2. LDPE Granules

The LDPE granules are used as the binding agent in the block formation process. As a result of the inherent plastic property of LDPE, test results indicate superior levels of crack resilience. The LDPE granules were added in percentages ranging from 50% upto 90% until an optimum range was obtained. Since molten LDPE is a viscous material, a very high or very low percentage of LDPE incorporation makes the mixing process difficult. Once heated, the molten plastic becomes unable to form a uniform blend with the sand particles in case of a lower plastic percentage (<60%). On the other hand, with a very high percentage of plastic (>85%), the block becomes susceptible to deformation.

Table 4 puts the characteristic features of LDPE that make this grade of plastic a suitable block ingredient.

Table 4. Design mix ratio of the test blocks [19]

Characteristic	Description
Lightweight	Makes it easier to handle and install
Moisture Resistance	LDPE has excellent moisture resistance, making it an excellent choice in humid climates
Insulation Properties	LDPE is a very good thermal and electrical insulator, making the end products both comfortable and safe
Cost Parameter	Inexpensive and readily available.
Durability	Has a long service life

Table 5. Design mix ratio of the test blocks

Sl. No.	Percentage of Plastic (%)	Percentage of Sand (%)
1	50	50
2	60	40
3	70	30
4	80	20
5	90	10

3.3. Mix Ratio

For the mix design, the sand grains were divided into 5 different grades based on their particle size. (Retained on IS sieve 2.36mm, IS sieve 1.18mm, IS sieve 0.6mm, IS sieve 0.3mm and IS sieve 0.15mm). Once the grading of sand was done, LDPE was introduced in percentages (by volume) of 50%, 60%, 70%, 80% and 90% to each of the sand grades. Table 1 shows the different mix designs of the plastic sand blocks.

3.4. Casting Procedure of the Plastic Sand Blocks

3.4.1. Batching

The plastic used for experimentation was virgin LDPE plastic granules. This was to ascertain if plastic mixed with sand can be utilized as an alternative to concrete in its highest possible state. After the attainment of the plastic granules, batches of the mix were formed as a percentage by volume to form the plastic sand blocks. The mix ratio of the batches is given in Table 5. Each of the mix ratios was formed in batches of 3, each of which comprised of 3 blocks. This was done to ascertain the accuracy of the strength parameters once the blocks were subjected to testing.

3.4.2. Mixing, Melting and Moulding

The plastic sand batches so formed as per Table 3 were transferred into the 7.06cm greased iron cube mould. Once the cubes were ready, the Hot Air Oven used for the purpose was warmed up for 10 minutes at 200ºC. The cubes were then subjected to heating in the Hot Air Oven for a duration of 1 hour and 30 minutes at 300°C. Midway through the melting process, the mould was taken out once after a lapse of 45 minutes and given a stir. Once the stipulated time was over, the plastic sand mix was allowed to cool for another 30 minutes, after which the mix was compressed by means of a compressing tool made of iron, as shown in Figure 1. Typically, the process of compression is carried out by means of a hydraulic compressor. However, since we are trying to create a technically simplified block, no such compressors have been utilized for this purpose. Demoulding of the blocks was carried out after 12 hours by means of hammering. Once demoulded, different parametric tests were conducted on the blocks within the next 72 hours. Simultaneously, together with the formation of the plastic sand block, 3 batches of 1:6 mortar block were also forged in the same standardized 7.06cm cube mould. This was done so that the values obtained after the different parametric tests could be compared against each other and a practical deduction could be made. The mortar cubes were subjected to testing after 28 days of curing.

Fig. 1 Compressing rod

Fig. 2 Greased 7.06 cm cube mold

Fig. 3 Hot air oven

Fig. 4 Virgin LDPE granules

4. Results and Discussions

Once the blocks were demoulded, different parametric tests were performed on the same in order to evaluate their strength parameters.

4.1. Compressive Strength Test

The compressive strength test was conducted to find out the load-carrying capacity of the blocks under compression. This test was performed with the help of a Universal Testing Machine wherein axial load was applied to the block until the first sign of cracking was witnessed, as shown in Figure 6. Figure 5 showcases the block prior to the load application.

The compressive strength test was performed after 72 hours of casting. The test results showed that with an increase in the plastic content of the block beyond 50%, there was an increase in strength value. At the time of demoulding, it was found that at 50% plastic content, there was not enough molten plastic to bind all the sand together. Binding became better as the value of plastic content was raised. This value kept on increasing with an increase in the content of plastic upto 85%, beyond which a decline was witnessed, as can be seen in Table 4. The decline witnessed was a type increase in the ductile value of the block beyond the requirement. It made the block easily bendable as there was not enough soil mass to give some structure to the block.

The displacement value shown in Table 6 has been noted at the point of crack commencement.

Fig. 5 Plastic-sand block prior to testing

Fig. 6 Plastic-sand block at the point of cracking

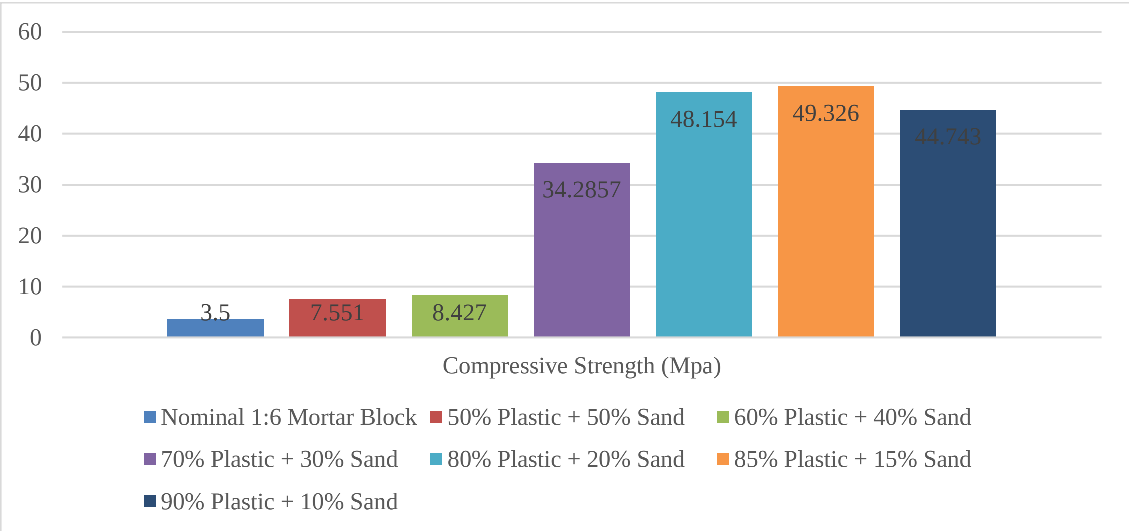

Fig. 7 Graphical representation of the plastic sand blocks as compared to 1:6 cement sand mortar block

Table 6. Compressive strength of the blocks with displacements at the point of cracking

Sl. No.	Design Mix	Peak Load (kN)	Compressive Strength (MPa)	Displacement (mm)
1	50% Plastic + 50% Sand	3.7	7.551	15.16
2	60% Plastic + 40% Sand	4.2	8.427	18.13
3	70% Plastic + 30% Sand	16.8	34.2857	24
4	80% Plastic + 20% Sand	24	48.154	28.74
5	85% Plastic + 15% Sand	26	49.326	31.27
6	90% Plastic + 10% Sand	22.3	44.743	26.24

Table 7. Water absorption test of the plastic-sand blocks

Sl. No.	Mix Design	Water Absorbed (%)
1	50% Plastic + 50% Sand	0.0
2	60% Plastic + 40% Sand	0.0
3	70% Plastic + 30% Sand	0.0
4	80% Plastic + 20% Sand	0.0
5	85% Plastic + 15% Sand	0.0
6	90% Plastic + 10% Sand	0.0

4.2. Water Absorption Test

The main purpose of the water absorption test is to check the amount of moisture the block will absorb once subjected to moisture. The test was performed in room temperature water (27°C), and the block was immersed for 24 hours. Before the immersion, the block was properly dried in the hot air oven to ensure complete dryness. The weight of the block was measured twice, once before immersion and once after immersion, to compute the water absorption value.

The test conducted as per the Indian Standard Code, IS 1077:1992, showcased water absorption of 0% after an incubation period of 24 hours, as seen in Table 5. It can be seen from the table that the absorption percentage is 0% even after 24 hours of submersion. This is because, firstly, the blocks thus formed contain no percentage of porous material, and secondly, the plastic that is used as a binding agent forms an impermeable layer on the surface of the block. As a result, the water becomes unable to seep through the surface of the block.

4.3. Split Tensile Strength Test

The split tensile strength test is a crucial assessment for evaluating the tensile properties of concrete and other composite materials. This test measures a material's ability to withstand tensile (pulling) stresses, providing valuable insights into how it performs under forces that induce stretching or pulling. It is significant because it helps predict the potential for crack formation in concrete, which is inherently weak in tension and prone to cracking under stress [21]. By understanding the tensile strength, engineers and builders can better anticipate and mitigate cracking issues in structures.

Table 8. Split tensile strength test of the plastic-sand blocks

Sl. No.	Composition	Split Tensile Strength (MPa)
1	50% Plastic + 50% Sand	3.2
2	60% Plastic + 40% Sand	3
3	70% Plastic + 30% Sand	2.8
4	80% Plastic + 20% Sand	2.5
5	85% Plastic + 15% Sand	2.2
6	90% Plastic + 10% Sand	1.8

The Split Tensile Strength values depend on the specific properties of the LDPE and sand used, the method of mixing, curing conditions, and the dimensions of the test specimens. In addition to evaluating material performance, the test serves as a benchmark for comparing different design mixes or alternative materials, such as sand-LDPE blocks. This comparison aids in selecting the most suitable material for specific construction applications. Table 8 showcases the strength values obtained.

4.4. Hardness Test

This test determines the resilience of the blocks thus fabricated against scratch. The specimen was subjected to scratching with scissors and nails to see if any impression was left behind.

Performed by means of scissors and nails, no scratch marks were seen on the blocks after testing, thereby confirming that the plastic sand blocks possess adequate hardness for use as a construction unit.

4.5. Thermal Resistance Test

The thermal resistance test is conducted to check the susceptibility of an object to fire or if any deformation of the object takes place at very high temperatures. Typically, weathering of buildings takes place over the years as a result of temperature fluctuations caused by seasonal changes. Since the block fabricated in this work of research is solely for the housing industry in India, the block must be able to withstand temperatures ranging from -40°C (Leh Ladakh) to 55°C. The Hot Air Oven has been utilized again for testing.

Once the fabricated block properly cooled off, any deformation due to temperature variation had to be checked so as to ensure the plastic sand block thus formed could be used in any part of the country with temperatures as low as Leh (-40ºC) or as high as Ganganagar (50ºC). Therefore, the set block was once again tested in the hot air oven at 100ºC for 2 hours. Once the stipulated time had elapsed, the block was taken out to be found only mildly warm with no softness whatsoever.

4.6. Thermal Conductivity

Low-Density Polyethylene (LDPE) is a type of plastic with relatively low thermal conductivity, typically around 0.33 to 0.45 W/m·K. Sand, on the other hand, has a higher thermal conductivity, generally ranging from 0.5 to 1.0 W/m·K, depending on factors like moisture content and compaction [20]. When combined with LDPE, the plastic-sand thus formed will have a thermal conductivity value depending on their respective percentage in the mix.

In case of low LDPE content, The thermal conductivity of the blocks will be closer to that of sand but still lower because LDPE has lower thermal conductivity. On the other hand, in the case of high LDPE content, the thermal conductivity will be closer to that of LDPE, which is lower compared to sand.

4.7. Efflorescence Test

The efflorescence test is typically conducted to check for the presence of salt in the block, as the presence of salt in construction materials tends to shorten the life span of the building structure.

No efflorescence was seen on the plastic sand block due to the unavailability of soluble salts or any salt in the plastic sand mix. This, in turn, ensures better durability of the housing structures as, in most cases, the presence of efflorescence can also be due to extent but not eliminated.

5. Conclusion

The experimental study conducted on the plastic-sand block gave a percentage range of plastic to be mixed with sand, which resulted in a building material stronger than concrete. This particular study involved very limited to no usage of high-end machinery like mixing devices or hydraulic compressors that should have been utilized otherwise. Machine means maintenance, and their intentional absence was to ensure the possibility of fabrication in places with accessibility issues. In addition to that, the blocks formed had to be affordable and have the least possible skill requirement. Thus, from this particular work research, the following conclusion can be drawn.

- The blocks that were designed gave the maximum compressive strength value of 48.154MPa with a displacement value of 28.74mm (when the first sign of cracking was observed), as can be seen in Table 4. This value was observed for the mix ratio of 20% sand and 80% plastic by volume.
- The high value of block displacement (as can be seen in Table 4) without cracking also proves that even if a structure can never be earthquake-proof, it can surely be earthquake-resilient. This level of deformation without disintegration shall provide ample time (way more than that given by the strongest, most stable concrete structures) for the residents to evacuate a structure safely before the collapse.
- Damping in a building not only reduces the shelf-life of the structure but also leads to molding that is responsible for different kinds of lung disorders. The blocks formed here are seen to be resistant to damping, as shown in Table 3. This indicates that there would be no requirement for any damp proofing in the structure, making the construction more economical.
- The absence of salt, as a result of the typical mix of sand and plastic, makes the block far more durable than ordinary concrete, which is always at risk for various reasons.

LDPE-sand blocks created from waste LDPE are recognized for their significant innovation in addressing environmental challenges through recycling and sustainable construction. By repurposing plastics that would otherwise end up in landfills, critical waste management issues are addressed, and a potentially cost-effective and energy-efficient building material is developed. Plastic waste is reduced through this approach, and a novel construction material with unique thermal insulation properties is introduced. Sustainable housing solutions are contributed to by these efforts, which may lower construction costs and improve energy efficiency, while material science is advanced and benefits are provided to underserved communities.

The experiment with plastic-sand blocks for building houses, incorporating waste LDPE and utilizing manual mixing, is expected to yield better results compared to other state-of-the-art techniques. The use of manual mixing is highlighted for its cost-effectiveness and simplicity, reducing the need for expensive equipment and making the production process more accessible. By directly addressing the problem of plastic waste, this method offers a practical solution to environmental issues, unlike some advanced techniques that may rely on new or processed materials. The flexibility in adjusting block composition allows for optimization based on specific needs, such as thermal insulation and structural strength, which might be more rigidly defined in automated processes.

In addition, the manual mixing technique supports local production and community-based recycling initiatives, potentially creating jobs and supporting local economies. The lower overall environmental impact of this approach is noted, as it minimizes the energy and resources required for production. Thus, the simplicity and accessibility of manual mixing combined with effective waste utilization provide a sustainable alternative to more complex, high-tech methods, contributing to both environmental and economic benefits.

6. Future Recommendations

Recommendations for further study can be summarised as follows.

- The mixing of the core ingredients, in particular, has been done manually using an MS rod. If, instead, the mixing was done by means of a heavy-duty injection molding machine or a plastic extruder machine whilst the heating took place, the block strength might increase significantly.
- The compressing mechanism of the block was performed manually by means of hand hammering. Utilizing a hydraulic compressor would result in better melt compression and, consequently, give superior strength values.

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