

RECYCLING OF WASTE PLASTIC MATERIAL FOR THE PRODUCTION OF TILES USING SAWDUST AS A REINFORCEMENT

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Abstract: Looking into how to make floor tiles that are kinder to the environment, this study used old plastic materials like LDPE and PET, mixed in wood dust plus added a substance called aluminium hydroxide to slow down flames. A total of fifteen different versions were made - each one blending five levels of wood dust (from 5% up to 25%) along with three grain sizes: small at 1.18 mm, medium-sized at 1.70 mm, and larger chunks measuring 2.36 mm - all shaped into slabs sized exactly 30 centimeters by 30 centimeters by 1 centimeters thick. Strength against bending was tested under an Indian standard method IS:3464-1986 using a formula written out fully as $\sigma = \frac{3PL}{2bd^2}$; while moisture pickup came from weighing samples before and after soaking them. As more sawdust went in, resistance dropped sharply - from highest point near 29.19 megapascals seen clearly when only 5 percent fine particles filled the blend - to weakest result just above 16.77 megapascals where chunkier grains formed heavier loads inside. Meanwhile, water intake crept upward opposite to strength loss - rising slowly from about 1.56 percent when little filler existed - to nearly six percent once maximum amounts crowded the mixture. Smaller particles always made tougher tiles that resisted water better, no matter how much sawdust was used. Results show these mixtures of plastic waste and wood dust can work well as floor coverings. Best results came when using between five and ten percent sawdust along with bits measuring 1.18 millimeters across.

Index Terms —Sawdust Reinforcement, Tiles, Flexural Strength, Water Absorption, Aluminium Hydroxide, IS:3464-1986, Sustainable Materials, Waste Recycling.

I. INTRODUCTION

Out here, fast factory expansion mixes with crowded cities - this boosts trash piles, especially plastics that won't break down and leftover crop bits like wood dust. When dumped without care, these mess up ground, pollute rivers, sour the air, and harm people's well-being. Turning these wastes into useful building stuff opens a smart path toward handling garbage better while pushing greener progress [1].

Most plastic items - bags, bottles, containers - linger far longer than needed since they resist natural decay. When sunlight strikes softer types, tiny but steady emissions of heat-trapping gas form. Dumping them adds strain; burning takes heavy effort, also lets out toxic smoke. Swapping recycled plastic into construction blends cuts damage while lowering costs quietly.

Out in the open, leftover dust from cutting wood piles up fast. This dusty waste often gets burned without care, sending smoke and harmful gases into the air. Made mostly of natural plant fibers like cellulose and lignin, it holds hidden potential. Those tiny fiber structures expose active bonding sites when mixed with melted plastics. Instead of vanishing in flames, these particles can lock into place within reused plastic blends. Strength comes quietly through physical grip and subtle molecular ties. Weight drops a little each time the mix shifts toward more dust. Costs shrink too, just by reusing what was once ignored. A quiet swap happens - less new material, less expense.

Tiles cover floors everywhere houses go up, shops open, factories run. Making usual ones needs lots of power along with materials like clay, feldspar, quartz - stuff that won't renew fast [4]. Developing tile products from recycled waste materials therefore addresses both resource depletion and solid waste accumulation simultaneously, aligning with the principles of circular economy and sustainable construction.

Aluminium Hydroxide $[\text{Al}(\text{OH})_3]$ is employed in this study as a flame-retardant additive at 5% by weight of the plastic fraction. Upon thermal decomposition above approximately 220°C , $\text{Al}(\text{OH})_3$ releases chemically bound water and generates an aluminium oxide barrier layer on the composite surface, retarding ignition and suppressing toxic smoke emission [5]. This property makes $\text{Al}(\text{OH})_3$ particularly suitable for interior flooring applications where fire-safety compliance is essential.

Out of discarded plastic mixed with wood dust, tiles take shape. Five mixes appear - each holds a different share: 5%, then 10%, climbing to 25%. Three grain sizes enter the blend: one fine at 1.18 mm, another wider at $\frac{4}{64}$ inch, last near $\frac{9}{64}$ inch. Bending force gets tested. Water soak follows close after. One mix stands out when both results line up. That version fits best underfoot where buildings rise. Floor by floor, it could replace older methods.

II. LITERATURE REVIEW

Bassey et al. (2017) investigated the reprocessing of LDPE waste sachets with sawdust for plastic ceiling tile production. Their results established an inverse relationship between sawdust particle size and tile strength, with finer particles (850 μm) yielding stronger composites. Composite strength also improved progressively with increasing sawdust loading, achieving maximum flexural and compressive strengths of 3.75 N/mm² and 8.83 N/mm² respectively at 50% sawdust proportion [6].

Hybrid ceiling boards made with sawdust, old paper, while using recycled PET held together by epoxy resin were examined by Amena and Hossain in 2024. Out of nine versions tried, one mixture stood out - containing 25% waste paper alongside 15% sawdust plus just 10% recycled plastic within a base of 50% epoxy, reaching 4.64 MPa in bending strength. When more recycled PET got added, step by step, water absorption dipped slowly, so did changes in size across the board surface. That pattern showed up clearly through their tests on how these materials behave when exposed to damp conditions [7].

From common trash, Remoto's group shaped a fresh idea by 2025 - tiles for floors born of discarded plastic, leftover wood bits, along with adhesive. Shying away from standard methods, their blend carried six-tenths plastic, one-tenth sawdust, three-tenths resin, reaching a mid-level flex strength just under 29 megapascals. That number? It blew past regular ceramic tiles by nearly half again as much. While normal tiles cracked under sudden force, every version of these held strong when dropped or struck.

Surprisingly strong, those mixes grab attention. Heat stays put when trapped inside them. Waste wood finds purpose here - nature keeps more trees. Performance climbs if tiny sawdust pieces join in just enough. Strength grows without tipping into heaviness. Balance matters most; extremes fall short [9]

One step at a time, research backs using mixtures of recycled plastic and sawdust for making roof panels. Earlier studies mostly looked into ceiling versions held together by epoxy or PVC materials. This one shifts focus - flooring gets tested instead. A melted form of reused plastic forms the base here. Added aluminum hydroxide helps slow fire spread. That twist hasn't shown up much in past work. Each piece fits differently than before. Knowledge grows - not replaced, just widened.

III. MATERIALS AND METHODOLOGY

3.1 Materials

The following materials were utilized in the fabrication of composite tiles:



(A) Waste plastic (LDPE/PET),



(B) Sawdust,



(C) Aluminium Hydroxide [Al(OH)₃]

(a) From nearby homes and city trash, used plastics like shopping bags, wrap materials, and drink containers were gathered. Not every piece melts the same - light polyethylene flows at about 115°C. Heavy-duty versions pack tighter, sitting between 930 and 970 kilograms per cubic meter. The clear stiff kind needs much more heat, turning liquid around 250°C. Each batch got picked by hand to separate types. After sorting, they took a rinse in fresh water. Drying happened without heat, just open air. Chopped into tiny similar-sized bits, the flakes melted evenly when heated later.

(b) From Ranjeet Saw Mill at Lakhadgunj in Nagpur came the sawdust. Under sunlight it sat for one to two days so any leftover dampness could fade away. After that, a series of lab-grade sieves sorted the material by grain width. Three separate groups formed - those held back at 1.18 mm, others at 1.70 mm, plus some above 2.36 mm.

(c) Fire resistance comes from aluminum hydroxide added each time - exactly 5 percent by weight of the plastic part - in every tile blend. This ingredient helps slow flames while keeping strength mostly unchanged across samples tested so far. Its role stays steady regardless of other changes in makeup. Performance under stress does not drop much even with this chemical present. Safety gains matter here more than minor shifts in toughness numbers.

3.2 Mix Proportions

Composite tiles of 30 cm × 30 cm × 1 cm were cast with a standardised total tile weight of 1000 g per specimen. The detailed mix proportions for each sawdust content level are presented in Table 1.

Mix ID	Plastic (g)	Sawdust (g)	Al(OH) ₃ (g)	Total (g)
M1 (5% SD)	902.5	50	47.5	1000
M2 (10% SD)	855	100	45	1000
M3 (15% SD)	807.5	150	42.5	1000
M4 (20% SD)	760	200	40	1000
M5 (25% SD)	712.5	250	37.5	1000

TABLE 1: MIX PROPORTIONS FOR PLASTIC–SAWDUST COMPOSITE TILES (TOTAL MASS = 1000 G)

3.3 Sample Coding

Each mix was further subdivided by sawdust particle size, yielding 15 mix designations in total (Table 2). Two tile specimens (T₁ and T₂) were prepared per designation for flexural testing (30 specimens total), and one additional specimen per designation was prepared for water absorption testing (15 specimens), giving 45 fabricated tiles in total.

Sample Code	Sawdust %	Particle Size	Plastic %	Al(OH) ₃ %
M1S1	5%	1.18 mm	90%	5%
M1S2	5%	1.70 mm	90%	5%
M1S3	5%	2.36 mm	90%	5%
M2S1	10%	1.18 mm	85%	5%
M2S2	10%	1.70 mm	85%	5%
M2S3	10%	2.36 mm	85%	5%
M3S1	15%	1.18 mm	80%	5%
M3S2	15%	1.70 mm	80%	5%
M3S3	15%	2.36 mm	80%	5%
M4S1	20%	1.18 mm	75%	5%
M4S2	20%	1.70 mm	75%	5%
M4S3	20%	2.36 mm	75%	5%
M5S1	25%	1.18 mm	70%	5%
M5S2	25%	1.70 mm	70%	5%
M5S3	25%	2.36 mm	70%	5%

TABLE 2: SAMPLE CODING

3.4 Tile Fabrication Procedure



(A) Mold oiling



(B) Mixing of materials,



(C) Compaction of tiles

Into a steel container went pieces of waste plastic, heated slowly till fully melted. Following that, dried sawdust - already sized correctly and weighed ahead of time - was poured in small amounts while stirring never stopped, just until everything looked evenly spread. Afterward, Aluminum Hydroxide entered the mix, stirred deep until no pockets remained untouched. Then out it

flowed, into a lightly greased mold made of soft steel, shaped exactly thirty by thirty by one centimeter, pressed down smooth so no bubbles could hide inside. Later on, the samples sat still, left to return to room warmth by themselves. One full day passed before anyone touched them - then they came out of their molds slow and got checked just by looking, searching for splits or empty spots along the face.

3.5 Flexural Strength Test



Flexural strength testing machine

Bending resistance got measured by way of a Flexural Testing Machine, following IS:3464-1986 - Methods of Test for Plastic Flooring. Using the typical setup with three points of contact, samples were set at specific sizes: width (b) stood at 300 mm, thickness (d) hit exactly 10 mm, while the distance between supports (L) reached 200 mm. From these values emerged the flexural strength (σ), derived through calculation based on that arrangement.

Three times P multiplied by L, then divided by two b d squared gives sigma.

$$\sigma = 3PL / 2bd^2 \dots\dots (1)$$

Equation one shows this relationship clearly

Where σ = Flexural Strength Of Tile (MPa); P = Max load (N), L = length of Span (mm); b = Width of Tile (mm); d = Thickness Of Tile (mm).

3.6 Water Absorption Test



(A) Dry weight of tile



(B) Submerged of tile



(C) Wet weight of tile

One tile specimen per mix designation was tested for water absorption. The dry weight (W_1) of each oven-dried specimen was recorded, after which it was fully submerged in still water at ambient room temperature for 24 hours. The specimen was then removed, surface-blotted with a dry cloth, and its wet weight (W_2) recorded. Water absorption percentage was calculated using:

$$WA (\%) = [(W_2 - W_1) / W_1] \times 100 \dots (2)$$

Where W_1 = Dry weight of specimen (g); W_2 = Wet weight after 24-hour immersion (g).

IV. SAMPLE CALCULATION

4.1 Flexural Strength — Specimen MIS1

Given: $P = 300 \text{ kg} = 300 \times 9.81 = 2943 \text{ N}$; $b = 300 \text{ mm}$; $d = 10 \text{ mm}$; $L = 200 \text{ mm}$

$$\sigma = (3 \times 2943 \times 200) / (2 \times 300 \times 10^2) = 29.43 \text{ MPa (T}_1)$$

For T_2 : $P = 295 \text{ kg} = 295 \times 9.81 = 2893 \text{ N}$

$$\sigma = (3 \times 2893 \times 200) / (2 \times 300 \times 10^2) = 28.94 \text{ MPa (T}_2)$$

$$\text{MIS1} = (29.43 + 28.94) / 2 = 29.19 \text{ MPa}$$

4.2 Water Absorption — Sample MIS1

Given: $W_1 = 900 \text{ g}$; $W_2 = 914 \text{ g}$

$$\text{WA} = [(914 - 900) / 900] \times 100 = 1.56\%$$

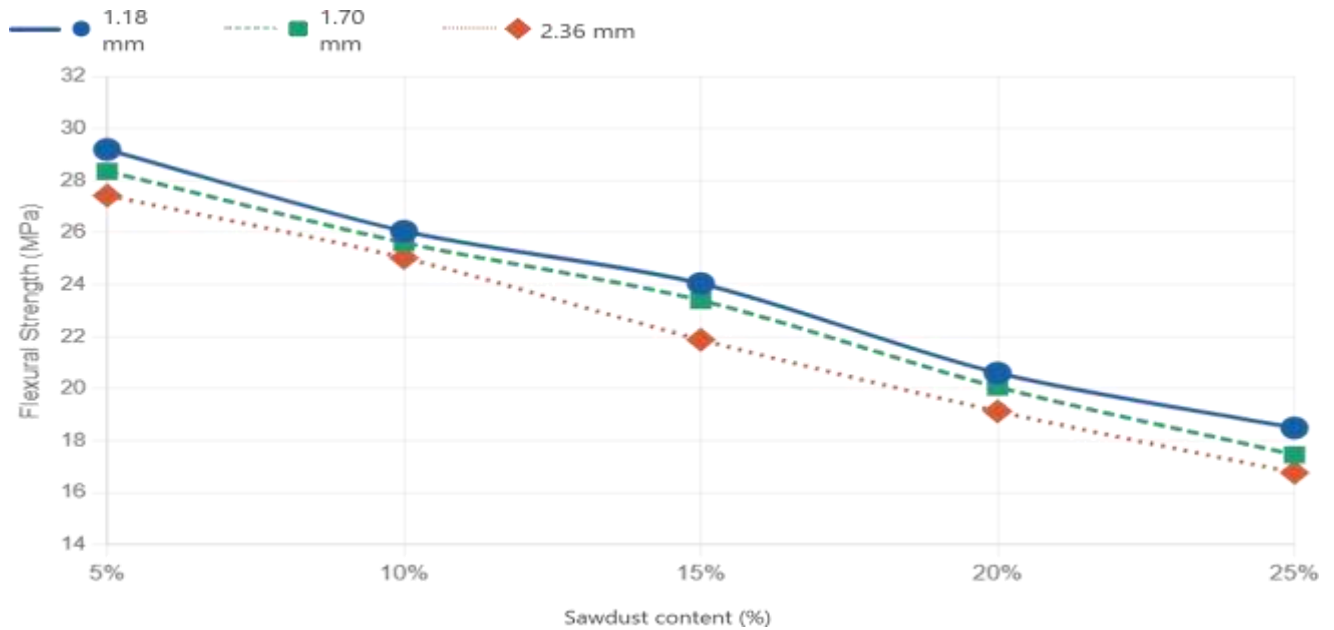
5.1 Flexural Strength Results

V. RESULTS AND DISCUSSION

Flexural strength values for all 30 test specimens are presented in Table 3. Two specimens (T₁ and T₂) were tested per mix designation and the average flexural strength computed for each designation.

TABLE 3: FLEXURAL STRENGTH OF PLASTIC-SAWDUST COMPOSITE TILES

Sample Code	Sawdust %	Particle Size	Tile No.	Max Load (kg)	Max Load (N)	Flexural Strength (MPa)	Average (MPa)
M1S1	5%	1.18 mm	T ₁	300	2943.00	29.43	
			T ₂	295	2893.95	28.94	29.19
M1S2	5%	1.70 mm	T ₁	291	2854.71	28.55	
			T ₂	287	2815.47	28.15	28.35
M1S3	5%	2.36 mm	T ₁	283	2776.23	27.76	
			T ₂	276	2707.56	27.08	27.42
M2S1	10%	1.18 mm	T ₁	268	2629.08	26.29	
			T ₂	263	2580.03	25.80	26.05
M2S2	10%	1.70 mm	T ₁	260	2550.60	25.51	
			T ₂	262	2570.22	25.70	25.61
M2S3	10%	2.36 mm	T ₁	253	2481.93	24.82	
			T ₂	257	2521.17	25.21	25.02
M3S1	15%	1.18 mm	T ₁	244	2393.64	23.94	
			T ₂	246	2413.26	24.13	24.04
M3S2	15%	1.70 mm	T ₁	241	2364.21	23.64	
			T ₂	236	2315.16	23.15	23.39
M3S3	15%	2.36 mm	T ₁	225	2207.25	22.07	
			T ₂	221	2168.01	21.68	21.88
M4S1	20%	1.18 mm	T ₁	209	2050.29	20.50	
			T ₂	211	2069.91	20.70	20.60
M4S2	20%	1.70 mm	T ₁	203	1991.43	19.91	
			T ₂	206	2020.86	20.21	20.06
M4S3	20%	2.36 mm	T ₁	199	1952.19	19.52	
			T ₂	191	1873.71	18.74	19.13
M5S1	25%	1.18 mm	T ₁	189	1854.09	18.54	
			T ₂	188	1844.28	18.44	18.49
M5S2	25%	1.70 mm	T ₁	179	1755.99	17.56	
			T ₂	177	1736.37	17.36	17.46
M5S3	25%	2.36 mm	T ₁	173	1697.13	16.97	
			T ₂	169	1657.89	16.58	16.77



Effect of sawdust percentage on flexural strength of tiles

Looking at Table 3, more sawdust means less bending strength. M1S1 showed the top result - 29.19 MPa - using just 5% sawdust and particles sized at 1.18 mm. On the flip side, M5S3 dropped to 16.77 MPa with 25% sawdust and larger grains of 2.36 mm. That drop lines up with earlier work from Bassey et al. (2017) [6], along with results seen by Remoto et al. (2025) [8]. Better performance tends to come when there's more plastic, plus smaller bits mixed in.

5.2 Effect of Sawdust Content on Flexural Strength

From start to finish, bigger chunks of sawdust didn't help things hold together better. When the mix went from 5% up to 25%, bending resistance kept dropping - no matter the size. Take particles measuring 1.18 mm: they started at 29.19 MPa but ended at just 18.49 MPa after five steps down. That's like losing more than a third right there. The ones sized at 1.70 mm fell off nearly as much - close to 38.5%. Even larger bits, say 2.36 mm, slipped about 38.9%. Clumping seems to be why it falls apart; too many wood specks crowd out space where plastic should grip tight. Once overloaded, forces move poorly across material lines. Same pattern showed up before in work done by Amena and Hossain two years ago.

5.3 Effect of Particle Size on Flexural Strength

Tiny sawdust bits made stronger tiles compared to bigger ones. When the mix hit 10% sawdust, strength dipped - from 26.05 down to 25.02 megapascals - as grain size jumped from 1.18 to 2.36 millimeters. Why? Smaller grains offer more surface area, letting the wood fibers grip the plastic better. More grip means force spreads out well under stress. That detail lines up with what Bassey's team noticed back in 2017 - every time, smaller particles gave tougher results, no matter how much sawdust was added.

5.4 Water Absorption Results

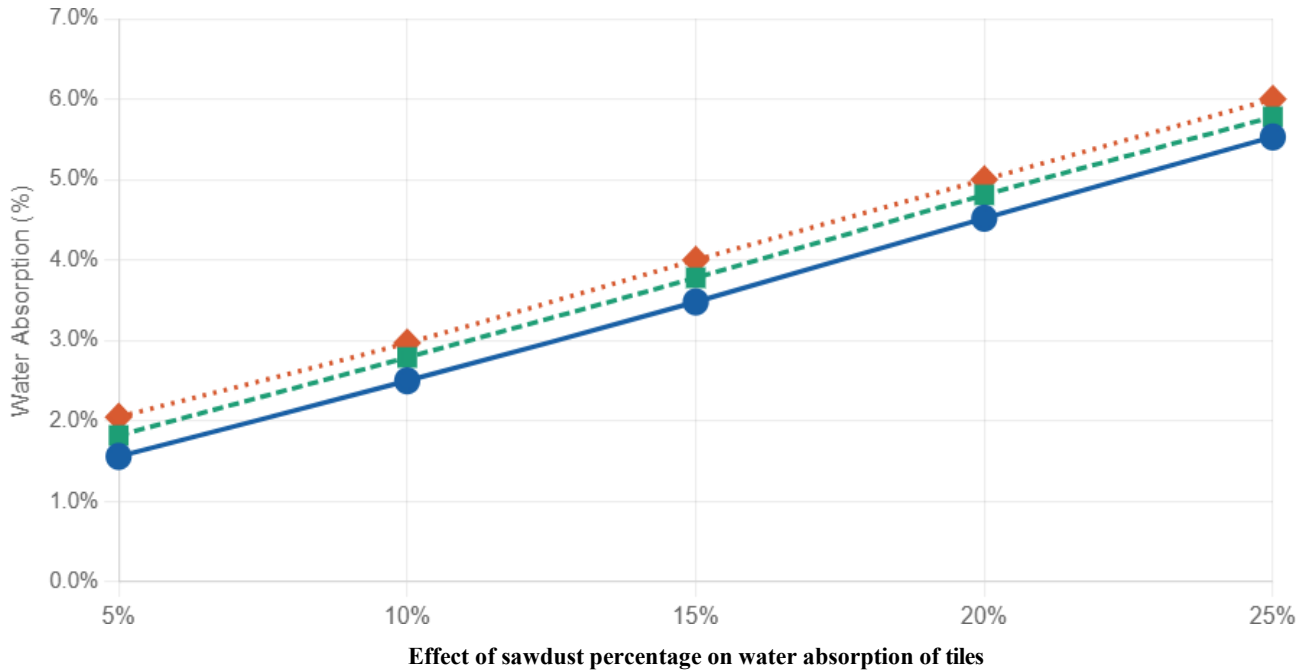
Water absorption results for each of the 15 mix designations are presented in Table 4.

TABLE 4: WATER ABSORPTION OF PLASTIC-SAWDUST COMPOSITE TILES

Sample Code	Sawdust %	Dry Weight W ₁ (g)	Wet Weight W ₂ (g)	Water Absorption (%)
M1S1	5%	900	914	1.56
M1S2	5%	990	1008	1.82
M1S3	5%	780	796	2.05
M2S1	10%	960	984	2.50
M2S2	10%	680	699	2.79
M2S3	10%	740	762	2.97
M3S1	15%	920	952	3.48
M3S2	15%	740	768	3.78
M3S3	15%	900	936	4.00
M4S1	20%	620	648	4.52

Sample Code	Sawdust %	Dry Weight W ₁ (g)	Wet Weight W ₂ (g)	Water Absorption (%)
M4S2	20%	997	1045	4.81
M4S3	20%	700	735	5.00
M5S1	25%	760	802	5.53
M5S2	25%	900	952	5.78
M5S3	25%	886	941	6.00

Table 4: Water absorption of plastic-sawdust composite tiles



From M1S1 to M5S3, water pickup climbed steadily - ranging from 1.56% up to 6.00%. Because sawdust holds onto dampness through its cellulose-rich structure, more coarse bits meant higher intake. Even when using the same amount of sawdust, samples with finer grains at 1.18 mm soaked up less. This happened since smaller pieces fit closer together while glue spread better across them. With fewer open pathways forming between tightly bound particles, water had a harder time moving inward. Findings here match earlier work by Amena and Hossain (2024) [7], where added plastic reduced wetting. Their explanation? Plastic filled gaps like a shield blocking tiny channels inside the material blend.

VI. CONCLUSION

Out of fifteen different mixes, each made by blending sawdust with waste plastic and treated with Al(OH)₃ to resist flames, came clear trends in how they bend and soak up water. Testing followed IS:3464-1986 methods closely. Results showed consistent patterns you can count on. Strength during bending dropped a bit when more additive was mixed in. Water crept into some samples faster than others. Each formulation behaved differently, yet one thing stayed true - adding flame protection changed how the material performed overall. Patterns stood out once numbers were compared:

1. Starting strong, M1S1 - made with 5 percent sawdust and 1.18 millimeter particles - showed top performance, hitting 29.19 megapascals on average. On the flip side, strength dipped lowest with M5S3, blending 25 percent sawdust at 2.36 millimeters, ending up at just 16.77 megapascals. Each mix told a similar story: more sawdust meant weaker tiles, no matter the grain size.
2. Smaller wood dust bits, about 1.18 millimeters across, handled bending better than bigger ones of 2.36 millimeters when used in equal amounts. These tiny particles also soaked up less water. The reason lies in how tightly they bond with surrounding material - more surface touch means stronger grip. Bigger grains leave looser connections.
3. Starting at 1.56%, water uptake climbed to 6.00% when more sawdust was added, going from 5% up to 25%. This shift came as the wood-based particles soaked up moisture naturally. At the same time, there was less plastic present to block water entry. Higher amounts of filler meant fewer barriers inside the material.
4. Moving from M1S1 toward M2S1 - where sawdust sits between 5 and 10 percent, sized at 1.18 mm - brings better bending strength alongside improved water tolerance, fitting well for indoor floor setups. Though material mix shifts slightly, the balance of durability and damp resistance stands out clearly within that range. Where performance under load meets humidity challenges, this span holds up more reliably than others tested so far.
5. When you add Al(OH)₃ - just five percent of the plastic's weight - the tile resists flames better while holding its shape under heat. Strength stays strong, barely drops at all. Because of this balance, floors made this way meet fire safety rules quite well.
6. Out of old plastic and sawdust, new floor tiles take shape - simple to make, kinder to the planet, cheaper than traditional options.

These materials team up instead of ending up in landfills, turning what was once trash into something useful. Not only do they cut down on pollution, but they also fit well within green building practices. Made from discarded bits, they hold their own against standard ceramic or concrete floors. Their creation supports smarter use of waste while meeting real-world needs. With them, buildings gain strength without leaning on heavy industrial methods.

ACKNOWLEDGMENT

Gratitude goes to Mr. Vikash R. Agrawal, Assistant Professor in Civil Engineering at Priyadarshini College of Engineering, Nagpur - his steady advice, technical insights, and backing shaped every phase of this work. Supplies came through Ranjeet Saw Mill in Lakhadgunj, which provided the sawdust used here. All tools and lab access were made possible by the Civil Engineering Laboratory team.

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