

**Alternative materials in civil construction: a comparison between the use of conventional and recyclable materials, bricks and concrete for sustainable constructions**

**Mauricio Dias Marques**

Master, Doctoral Student, UNESP, Brasil.  
md.marques@unesp.br

**Vitor Hugo Santana da Silva Quatroque**

Master's student, Unesp, Brasil  
Vitor.quatroque@unesp.br

**Rebeca Delatore Simões**

Professor, UNESP, Brasil.  
rebeca.simoes@unesp.br

**Sérgio Silva Braga Junior**

Professor, UNESP, Brasil.  
sergio.braga@unesp.br

## ABSTRACT

Civil construction causes environmental impact, as it consumes natural resources and generates a large amount of solid waste, raising concerns about the survival of future populations. Therefore, there has been a search for sustainable materials, to add non-conventional materials to the mass that forms bricks, blocks, pavements or make up walls in mud constructions, saving cement, sand, lime and stone. This work aims to present the aggregates that have already been experimented, tested, and that can compose the raw material with less disastrous results to the environment. A review was made in the literature, where articles, monographs, dissertations that address the subject were found. From them, a collection of the viability, opportunity and positivity of the use of aggregates was made, bringing a comparative result. The research can be useful as a basic element to guide those who intend to apply such materials, as well as to trigger and subsidize new studies, with new tests and experiments, both of these materials presented, and others that may still arise.

**KEYWORDS:** Sustainable Construction. Aggregates. Sustainable Materials. Mechanical Performanc.

## INTRODUCTION

The construction industry is one of the fundamental pillars of any economy, however, its expansion and magnitude demand caution due to the potential environmental impact. The sector, notoriously polluting, entails a series of consequences for the environment, from carbon dioxide (CO<sub>2</sub>) emissions during the production of clinker, a component of Portland cement, to the generation of waste from construction, maintenance and demolition processes (CHARITA et al., 2021). Therefore, the adoption of less aggressive techniques and products to the environment is urgent.

The construction sector plays a significant role in Brazil's economy, providing direct employment to 1,977,927 individuals and stimulating the trade of raw materials (IBGE, 2022). Despite its importance in creating infrastructure and spaces for housing, work and leisure, the sector is notorious for its high consumption of natural resources and the significant generation of waste in Brazilian cities (JOHN, 2017; ABRELPE, 2022).

In the light of this scenario, the perspective of sustainable construction arises, as an approach that prioritizes the principles of the "green economy" and the implementation of practices that improve socio-environmental performance (CNI; CBIC, 2012). This is reflected in the careful selection of materials less impactful to the environment and human health, from the initial phase of the project to the execution of the building.

One of the aspects of sustainable construction is the search for non-conventional materials, such as waste from natural raw materials, whether of mineral, vegetable or animal origin (CHARITA et al., 2021) or even with residues considered non-toxic, such as glass, wood scraps (MDF, MDP) and by-products of the construction industry itself, such as plasters and concretes (CONAMA, 2002). These materials can partially or fully replace the conventional components of concrete (cement, sand, gravel and water).

An important milestone in this search for sustainable materials is Resolution No. 307 of the National Environment Council (CONAMA), which classifies Construction and Demolition Waste (CDW) into categories that can be recycled for use as concrete aggregate, class "A", those that can be employed in other areas of construction, class "B", waste still without technology to be recycled and employed in construction, class "C", and finally waste harmful to health, class "D" (CONAMA, 2002). The positive impact of the resolution is mainly in its function as a guide for state policies that end up reducing waste and the generation of CDW in the construction sector (SÁ, MALHEIROS, SANTANA, 2018). Another important point is the fact that Resolution

307 is aligned with the UN's 2030 Agenda, specifically with the Sustainable Development Goals (SDGs) No. 11 and No. 12, which aim to improve the quality of life and reduce the environmental impact of cities.

This study seeks to present results and conclusions of experiments with different waste and alternative materials used as "new aggregate material", from the perspectives of various authors who explored such experiments.

## **METODOLOGY**

This study consists of a literature review that encompasses the analysis of articles, dissertations, and theses related to the use of different types of aggregates in the composition of materials used in civil construction.

According to Noronha and Ferreira (2000), the literature review is characterized by the selection of the most relevant works, comparison, and integration of the main approaches on the topic, in addition to gathering recent publications to offer an updated interpretation of the case studied.

The data used in this article are part of a larger work in which they were obtained through extensive research carried out on the Capes Periodicals Portal, which houses several renowned databases, such as ACM Digital Library, Library, Information Science & Technology Abstracts, Nature, Oxford Journals, Science (AAAS), Scopus, among others. The searches were directed to terms such as "models of sustainable civil construction"; "sustainable construction" and "materials"; "types" and "sustainable construction"; "sustainable civil construction" and "methods"; "sustainable civil construction" and "techniques or materials"; "modes of sustainable civil construction"; "sustainable civil construction"; "materials" and "sustainable construction".

From this selection, the publications that addressed the aggregates used in the composition of materials for civil construction were prioritized. The comparative analysis between their different types was carried out by the authors of this article, synthesizing the conclusions obtained by researchers who conducted experiments with the materials described in the literature review.

## **RESULTS**

Presented here are individualized results from the use of various unconventional materials that have been introduced as either complete or partial substitutes for conventional materials in the original composition of artifacts or pieces used in civil construction.

### **Aggregate with Red Ceramic**

In the study by Pins, Paliga, and Torres (2021), there was a substitution in the binder and the aggregate by portions of Red Ceramic Waste (RCW). The chosen traces were 1:3 and 1:6 (cement: aggregate). For binder substitution, 5% and 10% of RCW were tested, and for aggregate substitution, 10%, 15%, and 20% were tested. The following were evaluated in the experimental program: axial compression resistance at 7, 28, and 63 days with 4 test bodies per age; axial flexural tensile strength at 28 days, with 3 test bodies; immersion absorption and capillary absorption at 28 days with 5 test bodies for each.

The authors concluded that the action of the RCW depends of its proportions in the mixture. In the cement and sand mortars, the flexural tensile strength behavior is better with less cement consumption (1:6 trace); while in compression resistance, the traces with higher cement consumption perform better. The mortars with aggregate substitution showed worse results, however, those with material substitutions by RCW showed good mechanical performance; in physical behavior, mortars with less cement consumption (1:6 trace) have better performances. Immersion absorption is different from capillary absorption. In general, the application of RCW is a reality for various types of mortars (substitution and trace), with vast possibilities for recycling this waste.

Kwai (2013) already defended the results presented by Pins, Paliga, and Torres (2021) as understandable. Kwai's (2013) work proposed to investigate the use of sustainable materials that would be applied in the construction of an Experience Center at UNESP in Rio Claro, under economic, social, and environmental aspects. His work is a guide for decision-makers in this construction.

The author also talks about the use of cement with CDW, blast furnace slag, and limestone powder; use of aggregates with construction waste, steel slag, sugarcane bagasse ash, rice husk ash, fly ash, red ceramic, unusable tire, and glass. Also, materials such as: wood, bamboo, earth, soil-cement brick, isopet, tubopet, plaster, steel frame and wood frame, thermoactives, glasses, paints (minerals and with PET).

### **Aggregate with fly ashes**

In Brazil, the largest producers of fly ash (from mineral coal) are the states of Rio Grande do Sul, Maranhão e Ceará, together these states produce 2.66 million tons/year (CIRINO et al., 2021). This waste, according to NBR 10004:2004, is considered Class I (Dangerous) in the leaching analysis and Class II A (Non-Inert) in the solubilization analysis CANDIDO ET AL (2016).

Vasconcelos, Barroso, Vieira, and Almeida (2019) conducted a study to evaluate the use of mineral coal ash, coming from a thermoelectric plant in Fortaleza/CE, in pavement layers, having concluded that they represent a viable alternative, both economically and self-sustainable. "Fly ashes are silico-aluminous materials, which result from the combustion of pulverized coal" (p. 3). Three materials were used: coal ash, soil, and hydrated lime, in four stages of an experimental program. "Mixtures M3 (50% soil + 50% ash) and M4 (95% ash + 5% LIME) were apt from a technical and environmental point of view to be employed in the proposition of structural pavement projects" (p. 15).

Kwai (2013), brings information that in the aggregate with fly ashes coming from the mineral coal of the thermoelectric plants, it is possible to reduce cracks, increase resistance, increase workability, and have a lower environmental impact. In Figure 1, can get an idea of the form of presentation of the fly ash.

Figure 1 – Fly Ash



Source: Crusherinc; Kwai (2013)

### Aggregate with Sludge, Water Treatment Plant Residue (WTPR)

Araújo et al. (2015) conducted a study on the utilization of sludge, a waste product from water treatment plants, in the production of sustainable construction materials (Figure 2). The aim was to reduce the environmental impact caused by the disposal of this waste into water bodies. The study involved consistency tests, granulometry, microscopy, and spectroscopy. It was demonstrated that the sludge can be used as a partial substitute for soil and/or sand, up to a limit of 5%, and that it contains iron and aluminum oxides and hydroxides, making it resistant after firing and with potential use in the production of sealing elements when mixed with cement.

Figure 2: Satellite image of the WTPR area (a); Drying lagoon in operation (b); Full drying lagoon (c); Waste disposal in an area next to the lagoon (d).



Source: Araújo et. Al. (2015).

### Aggregate with PET and/or Isopet

Paschoalin Filho et al. (2019) developed interlocking concrete pavement pieces, using flaked Polyethylene Terephthalate (PET) waste as a sustainable alternative for the disposal of these wastes and replacement of part of the natural aggregates. Compression strength tests, water absorption, and monetary viability were carried out.

Eleven mixtures were studied, divided into two groups (G1 and G2). In the first group, mixtures with different percentages of replacement, by volume, of fine and coarse aggregate by PET (2.5%, 5.5%, 9.5%, 15%, 22%, and 36%), except for the first mixture (standard) without the use of PET. The second group did not have PET waste in its composition.

Products with the addition of PET had higher costs than conventional ones and there was a trend of decrease in compression strength with the increase of the PET percentage. However, the compression strength was close to that of the control group and met the current standards. In addition, products with the addition of PET showed better performance in water absorption.

Marques et al (2016), studied the effects of incorporating PET bottle waste into Polyurethane (PU). The test specimens were prepared with proportions of 35, 45, and 50% of PET in PU matrix, incorporating flame retardant, alumina. Thermal insulation, acoustic, mechanical resistance, and flammability tests were carried out. It was concluded that the incorporation of PET waste does not affect the thermal and acoustic insulation of PU, but reduces its mechanical resistance. The addition of flame retardant improves mechanical resistance and the fire resistance. This is a viable alternative for the reuse of PET, since the material presented visual uniformity and preserves the thermal and acoustic properties of PU.

Kwai (2013), reports that the interlocking ISOPET blocks (Figure 3) are made of lightweight concrete with recycled expanded polystyrene (EPS) and use whole recycled plastic bottles, horizontally or vertically. They have side fittings in the form of male and female (protrusions and recesses) that generate interlocking. Its use contributes to the reduction of the extraction of natural materials, such as sand, electricity consumption, human and mechanical, in addition to the advantages of lightness, low cost, and thermoacoustic improvements.

Figure 3 – Isopet block



Source: TIOGEGECA; Kwai (2013).

### **Aggregate with construction and demolition waste**

Bessa et al. (2019) evaluated the mechanical behavior of compressed earth blocks and masonry produced with CDW, focusing on compressive strength, absorption, and durability. The study showed the technical feasibility of using CDW in eco-efficient components, in association with materials of lower environmental impact, proving the compatibility between the soil, the CDW, and the cement.

The research conducted by Bins et al. (2021) investigated the use of CDW in interlocking concrete floors in the paving of roads, parking lots, and sidewalks. In substitution to

the fine aggregate, four dosages of CDW (0%, 25%, 50%, and 100%) were used, and tests of compressive strength and water absorption were carried out. The results showed non-compliance with the normative requirements established by NBR 9781 (ABNT, 2013) regarding compressive strength and water absorption. However, the dosage of 25% CDW showed potential for use in light traffic floors.

Another research, conducted by Waskow, Santos, and Tubino (2019), focused to identify, from a static point of view, a set of CDW samples, in substitution of the natural aggregate, and identify the possibilities of applications of the same. Three sets of samples were defined (mortar, concrete, and ceramic: CA1: ceramic and concrete; CA2: mortar and ceramic; CA3: mortar and concrete), with two types of materials, being able to determine values of mortar and concrete and ceramic. The conclusion was that the CA1 set is more suitable for mortar residues, the CA2 for concrete residues, and the CA3 for ceramic residues. The CA3 can be applied to any of the three sets of samples.

Lima and Santos (2020) search to evaluate composites of different traces or different compositions of soil-cement and CDW, for future application in sealing bricks in popular housing on the Island of São Luís - Brazil. Test bodies were made with 20, 40, and 60% CDW in addition to the soil and cement mixture; after curing, these were subjected to analyses of technological properties (soil granulometry test, linear shrinkage, compressive strength, and water absorption). It was concluded by the feasibility of certain compositions and that it is a viable alternative, both technologically and ecologically compared to conventional bricks.

Patricio et al. (2013) evaluated the use of CDW as a pozzolanic agent in the manufacture of soil-lime blocks. The residues were separated from undesirable materials, benefited by a jaw crusher and a pug mill, sieved, and stored in plastic bags. The soil was air-dried and sieved. The following tests were applied: real specific mass, specific area, granulometric analysis by sieving and laser diffraction, limits of liquidity and plasticity, chemical analysis, and X-ray diffraction. Test bodies were formed with substitution of lime by residues in the proportions of 0, 10, 25, 30, 40, 50, and 75%, and cured for periods of 28, 60, and 90 days, being determined simple compressive strength and water absorption. The results pointed to technical feasibility in the use of CDW for use in the manufacture of soil-lime blocks without structural function, since they evidenced superior values to the conventional ones.

The study by Lima and Lima (2020) suggests the incorporation of cement and sand mortar residue, from the laying and coating of walls, in the production of soil-cement blocks, for closures and vertical seals of dwellings. Studies, tests, and analyses of the technical performance of the molded blocks were carried out, with traces with 12.5% cement and 0%, 20%, 40%, and 60% residue in substitution to the soil mass. Absorption and durability tests were carried out at 7 days, and simple compressive strength at 7 and 28 days. The results showed that all traces with residue are indicated for making compacted earth block, soil-cement-residue, and the one with 20% residue had better results.

Silva et al. (2017) presents a study in which the applicability of blocks made with rubble generated from civil construction is analyzed. Articles and books related to the subject were sought, as well as the Civil Engineering laboratory of PUC-MG was used for the tests and the facilities of the company Projetar Ladrilhos e Artefatos de Concreto for molding and production of the blocks. It was concluded that the block of residues is inappropriate for structural use or sealing, even being similar in terms of resistance to the traditional block. In fact, the experiments identified that "the blocks ... of civil construction waste, of the plant of the City Hall of Belo

Horizonte ... cannot be employed in the civil construction industry for any functions, ... because they do not have a minimum characteristic resistance of 3.0 Mpa” (p. 39).

The researchers Pederneiras et al. (2020) analyze the behavior of concrete blocks produced with CDW. A substitution of 100% of natural fine and coarse aggregates by recycled aggregates was made in the manufacture of the blocks. Mechanical resistance and water absorption were evaluated, and extra tests on their microstructure. It was observed that there are no significant differences between these blocks and the reference sample (0% CDW). Satisfactory results for application in low movement and low load streets, sidewalks, and gardens.

According to Kwai (2013), the recycled aggregate (CDW) can act as a partial substitute for the natural aggregate, for the same trace, without loss of resistance. These residues, if mixed in a mortar or in some concrete in correct proportions, do not negatively impact.

### **Aggregate with mining waste**

Dyer et al. (2022) evaluated the technical and economic feasibility of using Waste Foundry Sand (WFS) as an aggregate in cement artifacts. They tested a mixture with 33% of WFS in cement mass, resulting in savings of 1 to 10% and benefits of WFS disposal. During the productive process of steelmaking, the sandy molds are discarded after use, generating a significant volume of WFS, which is mainly composed of silica (mineral sand), traces of metals (from casting) and resins (used as binders). The reuse of WFS as an aggregate in artifacts or cement blocks (without structural function) is not only feasible but also brings economic and environmental benefits.

Ramos Filho et al. (2021) studied the joint application of scheelite residue and stone powder with lime and cement, formulation in 50% of each residue, 6% of cement and 12% of lime. Tests of Simple Compressive Strength (RCS), Water Absorption (WA) and analysis of chemical phases by Scanning Electron Microscopy (SEM) and X-Ray Diffraction (XRD) were carried out, presenting promising results for use in the manufacture of cementitious construction materials. It is feasible in the manufacture of bricks and construction blocks, highlighting the rational use and the contribution to the reduction of environmental impacts.

The research by Costa, Gumieri, and Brandão (2014) shows the technical feasibility of using sinter feed waste, from iron mining activities, in the production of concrete for precast elements for paving. Tests of physical, chemical, and environmental characterization of the waste, physical characterization of the other aggregates used and quality of the waste regarding compressive strength were carried out. The pieces for interlocking floor were subjected to tests of compressive strength, absorption, and abrasion wear, by sampling. It was noted that the great relevance of the use of sinter feed waste is environmental. It is a granular waste from the iron ore production process subjected to washing and screening operations, without contaminants and with reasonable granulometric regularity. It has been deposited in piles near the steel mill, with heights close to a five or six-story building and contains a significant amount of iron.

Uliana et al. (2015) conducted a study on the use of the sawdust residue from ornamental rock blocks, which after thermal treatment and grinding becomes a slurry with potential application as a partial substitute for cement. Thus, it presents pozzolanic characteristics. Approximately 25% of each sawn block is converted into residue with water from sawing. The thermal treatment of this slurry from the beneficiation of ornamental rocks (LBRO) can produce a pozzolan to be applied as a filler in cementitious matrices replacing the cement



and maintaining the resistance at low substitution rates. They have even higher compressive strengths and elasticity. Its application is considered promising.

### **Aggregates in earth construction systems**

Nakagawa (2017) brings comments on earth construction systems: Adobe, compressed earth block, and rammed earth.

Adobe is a mixture of clay, sand, water, and straw usually in brick format. The mixture is placed in molds, dried in the sun, and removed after curing (15 to 20 days), after these process the mixture is ready for use. Then, the construction is carried out as with the conventional brick but using earth mortar. Figure 4 illustrates the sequence of adobe brick production. It is highlighted that it is a natural, economical, resistant, and highly durable construction method as long as the walls are protected from moisture and rain. It produces thermal comfort, does not require skilled labor, but needs to be sealed because the straw in its composition can provide lodging for the barber bug. The Compressed Earth Blocks (CEB), Figure 5, also known as ecological bricks, are made of clay, sand, and water, pressed, and removed from the mold immediately. Its mold and fittings help control the plumb.

Rammed earth is a “mixture of clay, sand, water, and straw piled (pounded), compressed between formwork, which are wooden or steel forms that are removable, removed as soon as it is completely dry” (p. 42). Thus, a wall is formed as resistant as a cement one, with natural thermal insulation, low cost, and fire resistant. The making of the formwork requires special attention, they should be resistant, or you can use the formwork only once leaving it as part of the wall. Figures 6 (a) and (b) demonstrate constructions in rammed earth.

Mendes and Bessa (2022) highlight rammed earth as an ancient technique that is being rescued due to the need to invest in sustainable constructions. It becomes a low environmental impact alternative when compared to conventional technologies. The evolution of contemporary rammed earth is analyzed in two aspects: technological analysis of the material and the construction system. Nowadays, in addition to the granulometric correction of the soil, natural or synthetic fibers and cement are added to improve the resistance and durability of the structure. However, the improvisation of equipment for mechanization can lead to waste of materials.

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Figure 4—production of estrutural adobe blocks



Source: Brandão (2009); Nakagawa (2017).

Figure 5— models of compressed earth blocks



Source: Farias Filho et al. (2011); Nakagawa (2017).

Figure 6 – Rammed earth: (a) contemporary construction, (b) process of wall production





Source: Brandão (2008); Nakagawa (2017)

### Plaster with Earth

Vitor, Lisbôa, and Librelotto (2020) evaluated the adhesion and applicability of earth plastering mortars, using two layers: roughcast, plaster, and final finish with whitewashing. They concluded that the categorization of the soil to be used in the preparation of these mortars is of great importance. The material is composed of mortar with the use of earth, the main material, plus additions with fiber, lime and/or cement, and was used for the finishing of an experimental prototype in bamboo, known as bahareque, a technique that uses bamboo to create the internal and external structural and sealing system. The most appropriate compositions and techniques for the plastering mortars were identified and the sealing and finishing were evaluated. The results validated the use of soil in the composition of mortars for plastering when characterized and studied on the need or not for stabilizing additives. Figures 7 to 10 demonstrate examples of the application of the earth coating.

Figure 7 – Scratch coat application with lime



Figure 8 - Scratch coat application with cement



Source: Vitor; Lisboa; Librelotto (2020)

Figure 9 – Plaster application



Figure 10 – Paint application



Source: Vitor; Lisboa; Librelotto (2020)

The researchers Durante et al. (2022) conducted an investigation on an innovative system, the Self-Compacting Soil-Cement (SCSC), a liquid mass composed of earth, cement, water, and additives, without great thickness, applied in molds without the need for vibration or compaction, a fast process, little cement, reduction of CO<sub>2</sub> and that can aggregate residues. The disadvantage is that it requires well-made molds that do not allow leakage. It can be used in housing settlements of agrarian reform.

#### **Eco-friendly brick (soil cement) or Eco-friendly block**

Research by Silva and Aguiar (2017) - (bricks made with banana peel powder, sandy-clay soil, and cement); Rocha et al. (2021) - (bricks with residues of crushed and hydrated eggshell and vinasse and water; Gonçalves et al. (2017) - (ash from sugarcane bagasse, sawdust, and PET); Segantini and Wada (2011) - (optimal dosage for soil-cement with CDW) account for the applicability of these materials.

#### **Discussion of results**

Table 1 demonstrates the advantages, disadvantages, result of a superficial analysis, and conditions of viability of use of the aggregates pointed out above, fruit of observations of the research works of the authors who carried out some experiment with the application of the residues as aggregate in the mixture of the mass for the manufacture of bricks, pavements, clay walls, and other materials for use in a sustainable construction.

**Table 1 – Summary of the advantages, disadvantages, and viability of sustainable materials**

<b>MATERIAL</b>	<b>Researcher</b>	<b>ADVANTAGES</b>	<b>DESAVANTAGES</b>	<b>RESULTS</b>	<b>VIABILITY</b>
<b>Aggregate with red ceramic</b>	Pins, Paliga; Torres (2021); Kwai (2013)	Better mechanical performance and physical behavior; < consumption of cement	Not provided	Positive	Yes
<b>Aggregate with fly ashes</b>	Vasconcelos; Barroso; Vieira; Almeida (2019); Kwai (2013)	Environmentally suitable; reduction of cracks; increase in durability resistance, increase in workability	Not provided	Positive	Yes
<b>Aggregate with sludge</b>	Araújo et al. (2015),	Resistant material, potential use in bricks, tiles and concrete mix	Not provided	Positive	Yes
<b>Aggregate with PET and/or Isopet</b>	Paschoalin Filho et al. (2019); Marques et al (2016); Kwai (2013)	Normal compression resistance; superiority of water absorption; does not alter thermo-acoustic insulation; lightness	Higher cost; decrease in mechanical compression resistance	Questionable	Yes
<b>Aggregate with construction and demolition waste</b>	Bessa et. al. (2019); Bins et. al. (2021); Waskow; Santos; Tubino (2019); Lima; Santos (2020); Farias Filho et. al. (2011); Patricio et al (2013); Lima; Lima (2020); Silva et al (2017); Pederneiras et al (2020); Kwai (2013)	Gains in environmental impact and costs; can act as a minimum partial substitute	Does not meet regulatory requirements; inferior durability; lack of minimum resistance; greater technological control of granulometric composition	Negative	Use without structural function
<b>Aggregate with mining waste</b>	Dyer et. al. (2022); Ramos Filho et. al. (2021); Costa; Gumieri; Brandão (2014); Uliana et al. (2015);	Economic and environmental benefits; promising results in the manufacture of bricks and blocks; environmental relevance; same resistance with low substitution levels	Not provided significant disadvantages	Questionable	Viable for non-structural function
<b>Aggregate with adobe and compressed earth block</b>	Nakagawa (2017)	Economical, resistant, with durability when protected from humidity and rain, thermal comfort	Rough finish; presence of the barber bug	Questionable, if there are no precautions	Yes
<b>Aggregate of rammed earth</b>	Nakagawa (2017); Nakagawa (2017); Mendes e Bessa (2022)	Natural thermal insulation; fire resistant; low cost; low environmental impact, energy reduction ambiental, redução de energia	Waste with equipment improvisation	Questionable	Yes

<b>Aggregate of plaster with earth: scratch coat, plaster and final finish)</b>	Vitor; Lisbôa; Librelotto (2020),	Adding fibers brings ecological benefit	May require stabilizing additives	Questionable	Yes
<b>Aggregate of soil cement self-compacting</b>	Durante et al. (2022)	Innovative system, which can incorporate waste	Need for molds that do not allow leakage	Negative, needs more studies	Not for now
<b>Eco-friendly brick or Eco-friendly block (adobe brick)</b>	Silva e Aguiar (2017); Rocha et al (2021); Gonçalves et al. (2017); Segantini; Wada (2011).	Reduction of environmental impact; saving of water resources; does not require burning; satisfies mechanical compression; < quantity of cement; protrusions and recesses allow perfect fit; light, reduces the weight of the work; > durability and resistance; thermo-acoustic insulation	Some point out low impact resistance, depending on the material used in its manufacture	Positive	Yes, better Wirth use as not estrutural propose

Source: Authors

From the observation of the considerations that support the studies carried out, for comparison purposes, it can be concluded that the aggregates with red ceramics, with fly ash, with water treatment sludge, and the ecological brick in which there is application of fibers, have a positive application, with the first three being totally viable and the last one will have its viability, most of the time, when applied in a non-structural function.

Doubt is cast on their application, the aggregates with pet or isopet, with mining residues, earth block, rammed earth, earth plastering mortar. Consider that the aggregate with pet is viable, despite the cost; the aggregates in earth construction systems are also viable, if the proper precautions are taken.

Already the aggregates with construction or demolition waste and the self-compacting soil cement become negative; the first one due to fragility and the second one because more in-depth studies have not yet been carried out. Even so, they could be used in non-structural functions.

### Final Considerations

An analysis of the materials that are entirely viable or partially viable to compose a product or material ingredient for use in civil construction was presented. There is the possibility of working with aggregates in the manufacture of blocks, in pavements, in mud walls, which make the construction cost lower and present great progress in relation to sustainability, as it takes from the “trash” something that can still be used, mitigating the environmental impact.

The classification pointed out in Table 1 can be useful for study or experience with the use of these materials, since an action can be carried out, with some basic element, knowing beforehand that the use or application of a certain material has already proven to be viable. Thus, this work contributes to science as a subsidy for new research, sustainability in terms of

the reuse of materials discarded by industries, and respect for the environment in terms of economy in the exploitation of natural resources.

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