

# Evaluation of waste plastics as recycled plastic composite materials

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## INTRODUCTION

Plastic is one of the key ingredient groups in the petrochemical industry, which uses petroleum-based products and natural gas as raw material, obtained by chemical conversion of these two. In addition to being lightweight; noncorrosive, soft, flexible, non-easily damageable its high heat and electrical insulation features make plastics an indispensable packaging material [1].

Because of socio-economic characteristics, Variety of consumption and differences in waste management programs; waste composition is different in each country. However, plastics rank first in the total amount of global waste. Four percent of the oil produced in the world is used in the plastics production. Plastics are mostly used in packaging and construction industries [2]. Polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), polyvinyl chloride (PVC) and polystyrene (PS) are the main types of plastics.

Since natural resources have decreased and environment pollution has reached to threatening size for humanity using recycled or waste materials which do not damage the ecological balance is one of the basic elements of sustainable building design. Construction industry is one of the areas in which plastic wastes can be used in large quantities in order to reduce the use of large amounts of natural resources such as aggregate and timber. Utilization of waste plastics in construction industry may also be helpful in reducing environmental problems such as reduction of landfill disposal and

preservation of non-renewable raw materials and prevention of environmental pollution.

## RECYCLED PLASTIC COMPOSITE MATERIALS

Besides the use of plastic waste as recycled material, a large amount of plastic wastes can be used in the construction industry as well. Waste plastics are used in construction industry as [3–13]:

- Aggregate in lightweight concrete
- Aggregate in asphalt concretes
- Fiber reinforcement in concretes
- Synthetic aggregate or binder in concrete (by melting)
- Resin in polymer concretes
- Component in artificial particle boards
- Plastic reinforcement in plasters

A large amount of natural aggregate is needed for production of concrete which is an indispensable material for the construction technology. While the cement has the largest proportion (40%) in the cost of production of one cubic meter, coarse aggregate comes in second with the proportion of 20% [14]. Aggregates are obtained from the quarries or natural aggregate resources. The increasing demand for new aggregate quarries has caused damage to the natural structure of the earth. Significant economic savings can be achieved and environmental damages due to the use of natural aggregates resources can be reduced by the use of recycled plastics as aggregate in concrete production. In the recent years, some experimental studies have carried out on using waste plastic granules as partial of full substitutes for natural aggregate in concrete composites [3–5].

Aggregate is one of the most important components of asphalt concretes. A large amount of plastic wastes can be used in the asphalt mixture by replacing with natural aggregate [6]. The recycling of plastic wastes for asphalt concrete roads has benefits about conservation of natural resources, reduction of solid waste landfill, energy saving and prevention of air and noise pollution.

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The studies about fiber reinforced composites have been increased specially after the banning of asbestos fibers. The addition of plastic fibers may improve the tensile strength, modulus of elasticity and toughness of concretes. They are normally used in the monofilament or wave forms, are hydrophobic. They do not have any effects on the hydration of Portland cement [7].

Waste plastics can be used as synthetic binder to produce composite material. In this method, waste plastics are mixed with sand and melted to produce a composite material like concrete [8]. Limestone, pumice, basalt and quartz sands may be used to produce synthetically binder composite with various colors and shapes by mixed with waste plastics [9]. In this way, waste plastics materials can be recycled without the need of separation process.

In recent years, the use of waste plastics in polymer concrete production has become another important issue. Polymer concrete is produced by replacing polymer with cement binders partially. Polymer concrete containing polyester resins based on recycled plastics was produced in 1991 [10]. In the last 20 years a lot of experimental studies were carried out on using waste plastics as resin in polymer concrete. In comparison to cement-based materials, the cost of polymer concrete production is very high because of the high cost of virgin resins [11]. Using waste plastics in the production of polyester resin decreases the cost of resin manufacture when compared to conventional normal resin production.

Plastic wastes can be used for production of artificial particle boards. Plastic wastes, wood chips and urea formaldehyde glue are mixed and shaped by pressing under a specific pressure and temperature [12]. Due to the characteristic of the plastic does not absorb water, this material can be used in the constructions where moisture problems.

Crushed waste plastics can be used with cement, cement-lime or only lime binders by replacing with aggregates to produce plaster material. The unit weight and water absorption values of recycled plastic plaster are lower than natural aggregate plaster. Plastic addition reduces the formation of cracks and reduces the thermal conductivity of the recycled plastic plaster [13].

## **STRENGTH, FIRE RESISTANCE AND INSULATION PROPERTIES OF RECYCLED PLASTIC COMPOSITES**

### **Strength**

In general, waste plastic aggregate incorporation causes reduction at compressive strength, flexural-tensile strength and splitting tensile strength of cement-based composites. The first reason of low strength of the composites is the low resistance of waste plastics. The second reason is the adherence between plastic and binder matrix is not strong enough as the bond between natural aggregate and binder matrix [15]. Therefore, plastic wastes are used as filler material or lightweight

aggregate in lightweight concrete composites instead of structural concrete production.

Due to the low unit weight of plastics the unit weight of recycled plastic concrete is low. This situation causes a reduction in the dead weight of concrete members of a building. Since the earthquake forces linearly dependent on the dead-weight reduction in the dead weight of a building will help to reduce the seismic risk of the building [3]. Since recycled plastic concrete shows more ductile fracture it helps to extend the time of building's collapse while preserving its integrity during the earthquake. In addition, waste plastic fiber reinforcement increased the toughness resistance of concrete and positively affects the energy absorption properties of concrete.

### **Fire resistance**

The fire resistance of recycled plastic concrete composites is lower than natural aggregate concrete. While conventional concrete resists up to 800°C, recycled plastic concrete loses its strength properties after 400°C. In addition, if plastics are exposed to high temperature toxic gases can be spread. Therefore, when using recycled plastic composite as a building material, the outer surface of the composite should be covered with high fire resistance material such as plaster, rockwool, glass wool planks.

### **Heat and sound insulation**

The buildings produced from recycled plastic composites exhibit higher levels of energy efficiency and comfort when compared with the conventional concrete building [16]. Plastic waste replacement with natural aggregate in concrete mixture causes a reduction in the values of thermal conductivity [15]. The use of recycled plastic composites as building shell can reduce the building's heating and cooling costs. Since the porous structure of recycled plastic composites ultrasonic pulse velocity value of recycled plastic composites is low. Therefore, reinforced plastic composites may be used as sound insulation material in construction industry.

## **CONCLUSION**

A structure made from recycled plastic composite materials has very important environmental features, such as resource efficiency, energy efficiency and reducing the environmental pollution. Recycled plastic composites can be a good alternative for lightweight construction materials and plastic recycling industry because of the properties such as low unit weight, low thermal conductivity and high insulation properties. In addition, recycled plastic concrete composites have a potential to reduce the dead weight of concrete members, and it could be helpful in the design of an earthquake resistant building. However, its effects on the environment and human should also be considered. For this reason, recycled plastic composite materials should be examined

during the building life cycle processes and then used for construction production after tested their performance under the influence of environmental conditions.

**Keywords:** Construction industry, Plastic concrete, Plastic composites, Recycled plastic, Waste plastics

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Semiha Akçaözoğlu – Substantial contributions to conception and design, Acquisition of data, Analysis and interpretation of data, Drafting the article, Revising it critically for important intellectual content, Final approval of the version to be published

#### Guarantor

The corresponding author is the guarantor of submission.

#### Conflict of Interest

Authors declare no conflict of interest.

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