# BEAM STRENGTHENING USING HONEYCOMB PLATES

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**Abstract -** Damages occurs in reinforced concrete structure due to labor defect, material imperfections, external conditions and earthquakes. The structural elements such as beam and columns are need to be strengthened. The most common method used to strengthen the beam is attaching steel plates to beam. In this study honeycomb plates is used to strengthen beam. A reinforced concrete beam is modeled and solved with finite element analysis and compared with a beam joined with honeycomb plate.

**Keywords -** Beam strengthening, honeycomb plates, finite element analysis.

## INTRODUCTION

The structural elements such as beam and columns are need to be strengthened in some cases. It is important to use lightweight materials for strengthening. Honeycomb composite structures are used in manufacturing where high mechanical strength is required, especially when the impact energy is reduced [1]. Honeycomb composite panels are used especially where the elasticity modulus is desired to be high, where the impact energy is absorbed and the elasticity against this force is required. Plywood panels of the desired thickness are glued on the two surfaces of the sandwich panels in order to obtain very light systems. Placing the honeycomb structure between the plates increases the inertia moment and bending strength of the structure[2]. For this reasonhoneycomp panels are attached to the beam for strengthening.There are many studies about honeycomb panels. In this study honeycomb panels were used for beam strengthening. 5 mm thick honeycomb panels were bonded to beam bottom surface with 1 mm thick adhesive. The model were solved using finite element model with Ansys. Results were compared with the bare beam. Honeycomb panels can be used for beam strengthening.

## II. METRIALS AND METHODS

### 2.1. Honeycomb Panels

New materials are needed with the increase of material demands in the construction area. For this reason new investigations have been made. In these researches, the use of composite materials has come to the forefront by combining different materials and successful results have been obtained in this area[3]. One of the materials that emerges as a result of the search for new materials is honeycomb composite[4].
The honeycomb composite technology was first used in the egg transport box in 1845. It was later used in the aviation sector in 1919. After 1940, it started to be used in aviation sector, in aircraft body panels. Honeycomb composite panels are composed of 1.5 to 8 mm thick lower and upper control panels. The core (honeycomb) consists of core pieces with a thickness ranging from 16 to 20 mm. The Honeycomb structure is very difficult to adhere to external surfaces, but forms core structures that form superior strength / weight ratios[2]. In Figure 1 and Figure 2, the honeycomb composite panel is shown schematically.

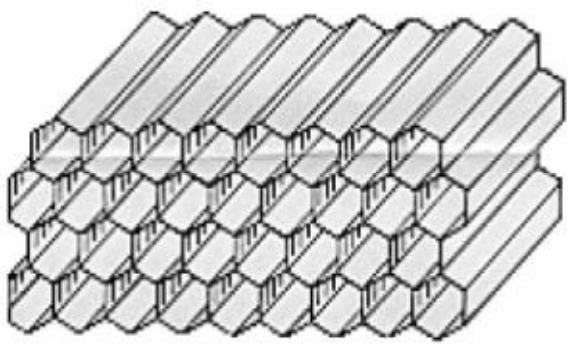


**Figure 1. Hexagonal honeycomb structure[1] .**

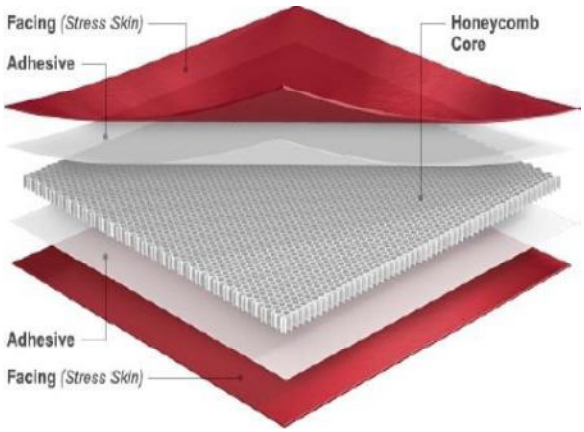



**Figure 2. Honeycomb panel structure[5]**

The honeycomb composite panels are widely used in space applications due to their high bending ability for low masses. To optimize the structural design, advanced materials such as high modulus composites are used. Aluminum alloy surface plates in traditional honeycomb sandwich panels are replaced by fibrous composite materials.This is especially true for structural elements like solar panels, antennae, etc.[6]. The honeycomb composite panel is primarily

used in civil and military aircraft due to its high strength and low weight. It is used on a large number of aircraft parts, including the civil aircraft industry, on floors, in door construction[2].

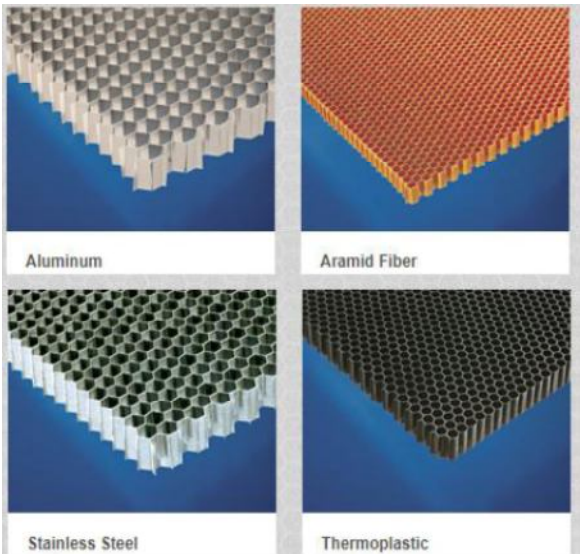



**Figure 3. Honeycomb cores[7]**

### 2.2. Strengtheninf of Beam

Concrete is known for its high compressive strength and relatively low tensile strength. For this reason, massive concrete structures such as thick walls, dams and nuclear power plants tend to form cracks in the form of thermal stress and cement particles separated from the hydration of the materials[8]. Many reinforced concrete structures composed of reinforced concrete frames are subject to significant cutting problems due to different reasons.

In general, although the torque capacities of these structures are sufficient, the failure of the shear strength leads to a frangible shear fracture [9]. Reinforced concrete beams should be strengthened when they are not sufficiently strengthened and subjected to higher loads, or when the bending forces fall below the bending capacity [10]. Various techniques are used to strengthen reinforced concrete beams. One of these methods is called layer addition. In this method a new reinforced concrete layer is added to the lower face and / or upper face of the beam. The new longitudinal fixtures are connected with the old fixtures 'U' and 'Z'. This method is very difficult to implement both as reinforcement and as long as it is successful in terms of ductile fracture. Especially the welds of the fixtures and the compression of the placed concrete cause the difficulty in applying [11].

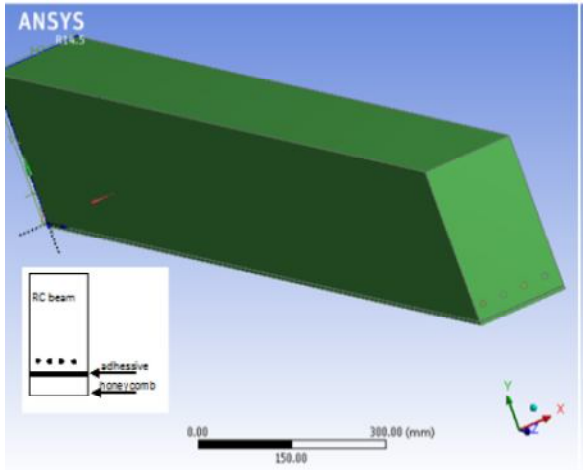
Another technique used in strengthening the beams is to improve the surface of the beams by attaching carbon-fiber fabrics. In this method, it is seen that sufficient ductility can not be obtained although the intended strengths are generally achieved. In addition, the fact that carbon fiber fabrics are very expensive and that importing them from abroad is a disadvantage. Despite these inconveniences, it has recently been widely used in our country[11]. Another method of strengthening is the bonding of steel plates to the beams. One of the widespread research topics is the method of reinforcing beams with strong adhesives using steel plates in recent years. The simplicity of implementation and the creation of economic costs with this method make the method attractive [9].

Significant ductility problems have also been observed in beams reinforced with steel plates. It has been observed that the end connections proposed for the steel plates in the works are insufficient to transfer the load on the plate to the beam ends, and at the progressing load stages, the plate end suddenly separates from the beam and breaks briskly. In this respect, what kind of material should be used for strengthening is of great importance [12]. With the emergence of composite materials new approaches have been developed to strengthen the shear value of reinforced concrete beams. Strengthening with composite materials can be developed with reasons such as high strength ratio, high durability, electromagnetic neutrality, ease of use, low work power, fast running[10].

Several research studies confirm that the shear capacity of reinforced concrete (RC) beams can be increased by using the fiber-reinforced polymer (EB-FRP) method, which is connected to the outside. However, the breakdown of the bonds, which are often the main cause of failure of such systems, will reduce the effectiveness of such a strengthening method [13]. For this reason, one of the things to be aware of when retrofitting techniques are used is the correct application of the bonding step.

### 2.3. Beam Model

5 mm thick honeycomb panels were bonded to beam (with 150*250*2400mm dimensions)bottom surface with 1 mm thick adhesive(Figure 4).



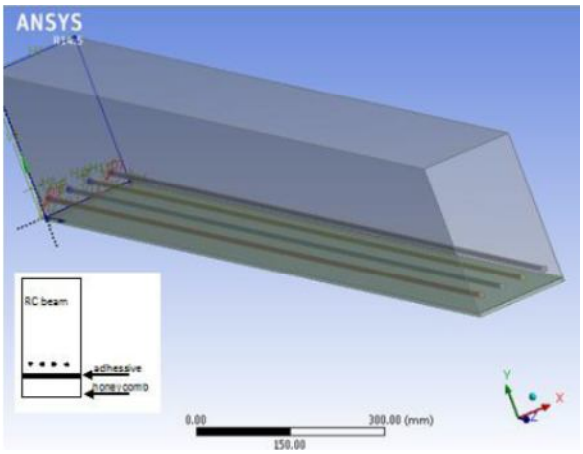
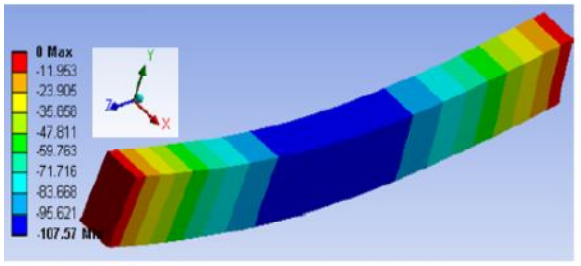


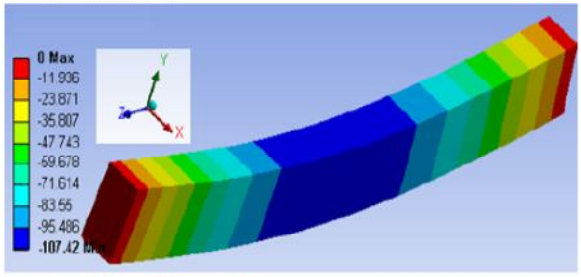

**Figure 4. Beam model with honeycomb panel.**

## III. RESULTS AND DISCUSSION

1 Mpa uniform pressure load is applied to a surface of beam. Beam was solved with finite element method. This beam was also loaded with 1 MPa uniform pressure. Two beams were solved with Ansys program and the deflection results and normal stress result were compared. The results were seen in figure 5 and 6. Maximum deflection decrease from 107.57 mm to 107.42 mm. Maximum normal stress of Z direction decrease from 1545.4 MPa to 1534.6 MPa.

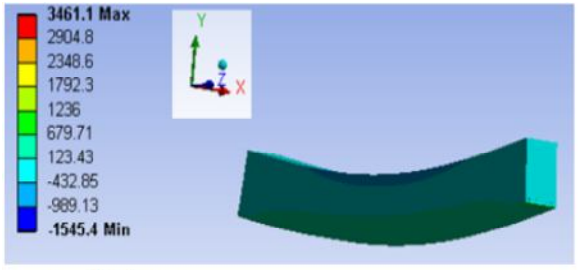



a. Barebeam

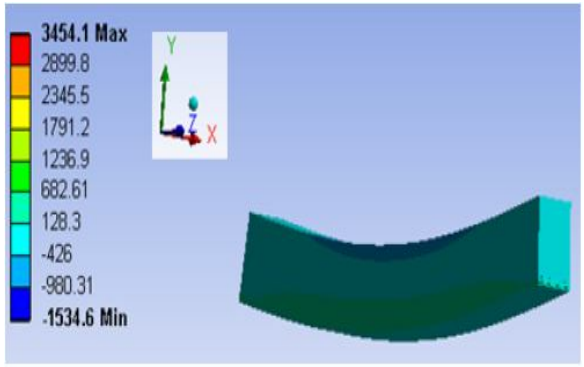



b. Beamwithhoneycomb

**Figure 5. Directional deformations results( Y axis)**




a. Barebeam




b. Beamwithhoneycomb

**Figure 6. Normal Stress results(Z axis)**

## CONCLUSIONS

Honeycomb panels were used for strengthening of beam. Beams were modeled and tested under constant loads. The following conclusions were drawn:

1. Total displacement slightly decreased with honeycomb panel.
2. Axial stress decreased by using honeycomb panel.
3. Thicker honeycomb plate will give better results.

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