CHAPTER 3

METHODOLOGY

3.1 OVERVIEW

In this chapter, materials characteristics, specimen details, laboratory testing, experimental works and methodology chart are discussed in details in order to carry out the experimental study with expected data and results. Slump test and compressive test were conducted to support this experimental study with the data and results that were collected. Procedure of the experimental works are explained in details with support of methodology chart. Thus, the progress of experimental study are cleared for understanding.

3.2 MATERIALS CHARACTERISTICS

In this section, the materials that used in this experimental study to build the RC deep beams with large circular openings are mainly focus on reinforcement steel bar and ready-mix concrete. Moreover, CFRP and epoxy resin that as the strengthened materials for the RC deep beam also discussed.

3.2.1 Reinforcement Steel Bars

For the reinforcement steel frame, the RC deep beams were installed with 2T10 of compression reinforcement bar, 2T16 of tension reinforcement bar, 7 vertical link of R6-300 and 3 horizontal link of R6-150. The nominal yield strength for the compression & tension reinforcement bars were 500 N/mm² and the vertical & horizontal link were
275 N/mm². Reinforcement steel frame was formed by tying all the reinforcement bars together according to the planning.

![Reinforcement steel bars of T10, T16 and R6](image)

**Figure 3.1:** Reinforcement steel bars of T10, T16 and R6

### 3.2.2 Concrete

The RC deep beams were cast using ready-mix concrete ordered from Hanson Building Materials Malaysia Sdn. Bhd. that located at No. A71, 1st Floor, Jalan Teluk Sisek, 25050 Kuantan, Pahang. In the ready-mix concrete, ordinary portland cement (OPC) with a 28 days compressive strength of 35 N/mm² was used because it was common and widely used in the concrete construction. Ready-mix concrete was produced by the combination of ordinary portland cement, aggregates, sand, water and additives. In this experimental study, a total 2 m³ of ready-mix concrete was ordered. Hence, all the RC deep beam were cast with the same batch of ready-mix concrete in order to obtain the same concrete strength and uniformity. Furthermore, the spacer block were cast with the combination of ordinary portland cement, fine sand and water as shown in Figure 3.3. Then, the thickness of the spacer block was same as the concrete cover that was 20 mm.
3.2.3 CFRP and Epoxy Resin

Two of the RC deep beams with circular openings were strengthened using CFRP which classified as surface strengthening (SS-BCO) and U-wrap strengthening (UW-BCO). Figure 3.4 presents the CFRP that come in one roll with thickness of 0.13 mm and provided with 230 kN/mm² of tensile E-modulus of fibers. Before the CFRP laminates were applied on the RC deep beams, surface preparation of the RC deep beams must be