CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Rapid development in some developing nations has encouraged the construction of high-rise buildings and sky scrapers. Due to the heavy load from the enormous buildings, deep beams are always constructed at the lower floors as transfer beams to transfer the load from the entire building to the foundations. Reinforced concrete (RC) as one of the most essential building materials and it is widely used in the construction due to its low pricing, efficiency and strength of the reinforced concrete as well as its stiffness (Dadvar, 2014). Thus, RC deep beams are playing an important role in tall buildings, offshore structures, and foundations (Kong, 2006). Sometimes, the creation of openings on the reinforced concrete (RC) deep beams is needed to accommodate the utility services conduits such as electrical wiring and piping (Hawileh et. al., 2012a).

Some of the researches and studies have been done on the RC deep beams with openings recently. Dadvar (2014) tested the behaviour of reinforced concrete beams and high walls with finite element analysis. Campione and Minafò (2012) experimentally and analytically evaluated the influence of circular openings in reinforced concrete deep beams with low shear span-to-depth ratio. Hemanth (2012) studied the behaviour of FRP strengthened deep beams with openings through experiments and numerical study by using ANSYS. Five deep beams with openings without shear reinforcements were tested under three-point loading. Another finite element analysis on simply supported RC beams with circular openings had been conducted by Hafiz et. al. in 2014. Alsaeq (2014) investigated
the usage of Carbon Fibre Reinforced Polymer (CFRP) to increase the structural strength of RC deep beams with openings.

1.1.1 Reinforced Concrete Deep Beams

RC deep beam which means the depth of the beam is comparable to the span length of the RC beam itself. However, the Eurocode 2 (1984) (draft): Common Unified Rules for Concrete Structures does not directly provide guidelines for the design of the deep beams. Instead, it is required to refer to clauses 18.18 of the CEB-FIP Model Code (1978). Moreover, the design is not covered in BS 8110 as well, this can be known from the statement that “for the design of deep beams, reference should be made to specialist literature”. This is similar to the Draft Eurocode 2 which explicitly states that “it does not apply however to deep beams...” and refer to CEB-FIP Model Code. The main design documents, recently, available are the American code ACI 318-83 (revised 1986), CIRIA Guide 2, the CEB-FIP Model Code and the Canadian code CAN-A23.3-M84 (Kong, 2006). However, American Concrete Institute (ACI) states that, in the ACI 318-08 code, specification of deep beam should have either clear spans equal to or less than four times of the overall member depth or regions with concentrated loads within twice the member depth from the face of the support.

1.1.2 Reinforced Concrete Deep Beams with Openings

In recent decade, techniques used on the openings in deep beams are improving and much advanced. Openings are needed nowadays to allow the installation of conduits for utility pipelines such as electricity, air conditioning, gas pipeline, fire-rescues system, and computer networks. Opening in deep beam sometimes is not constructed together during casting of the RC deep beam but it is necessary to be made from core boring method on the RC deep beam on the existing building. The load path will be changed and shear capacity of the RC deep beam will be reduced if the openings intercept the stress field of the loading and the reaction point (Campione & Minafò, 2012). Several of shapes and
sizes of openings could be found on the openings of RC deep beams, generally, the openings in the area where shear is dominant which is near to the support (Hafiz et al., 2014). Openings are inevitable now due to its convenience for the utility pipelines and most important it can reduce the overall story heights of buildings by creating openings on the RC deep beams.

1.1.3 Finite Element Analysis by ANSYS Civil FEM 12.0

ANSYS CivilFEM 12.0, a structural modelling and analysis software, is used for finite element analysis by numerical method and modelling of RC deep beams with openings is done in 3-Dimensional. ANSYS CivilFEM 12.0 is a high-end solutions for advanced civil engineering projects. ANSYS CivilFEM 12.0 can be used for creating engineering solutions spanning static, dynamics, linear and non-linear problems. This civil structural software is capable for structural elements and the checking code included Eurocode, Russian SP, ACI, Brazilian Code, ASTM, British Code, AISC and Chinese Code (https://caeai.com/ansys-software-support/civilfem-ansys-software). Moreno et. al. quoted that “CivilFEM is at the present time one of the most advanced tools that engineers can embrace, a project that is committed with a time and with a permanent vocation of investigation and development.” (Moreno et. al., 2001).

Finite element analysis is a numerical method to solve some complicated problems. Numerical solutions can now been obtained through finite element analysis for even very complicated stress problems (Roylance, 2001). Finite element analysis can be applied in many areas of studies, e.g. structure analysis, solid mechanics, dynamics, thermal analysis, electrical analysis, biomaterials and etc. Finite element analysis is originally developed for solving solid mechanics problem. At first, input such as boundary conditions will be set into ANSYS CivilFEM 12.0 and the software will provide output, for examples, stress, strain, displacements, load-deflection diagram and deformation of the models.