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LONG TERM DEFORMATION OF BEAMS AND COLUMNS OF HIGH PERFORMANCE CONCRETE

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ABSTRACT

The columns of a building must be stronger than the beams. The aim of this study is to obtain the cause of the long-term deformation difference by shrinkage between the beams and columns of high performance concrete with compressive strength of 60 MPa. This research was done experimentally in Indonesia during 410 days. Specimens measuring 150 mm × 150 mm × 600 mm were used, 3 pieces for the beams and 2 pieces for the columns. Deformation was obtained by using an embedded vibrating wire strain gauge for each specimen. The difference of long-term deformation in columns and beams is in their autogenous deformation behavior. This is because during the autogenous phase, swelling abnormally occurs in the column before shrinkage occurs. The abnormal swelling is caused by the press of its own weight. This phenomenon does not occur in beams. In the age range of 1 to 200 days, the behavior of the beam deformation has a similar pattern to the deformation behavior of the column with a high deformation rate. After that, at 200–410 days, column deformation changes to a very slow deformation rate. Long-term deformation in columns is lower (64%) than in the beams at 410 days age.

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1. INTRODUCTION

Deformation is the most important mechanism in structure. The understanding of deformation makes structure designers have certain descriptions that are needed in designing. Long-term deformation prediction is important to make the design effective and efficient. Deformations in concrete occur naturally right after casting. It is caused by the hydration process. Long-term deformation is a deformation in the time span of 170–1,000 days (Pons et al., 2003), while the hydration time period is estimated to be 416 days (Morin et al., 2002). Deformation is also affected by pozzolanic admixture (micro silica, silica fume and high reactive metakaolin). Pozzolanic admixture and fiber have been proven and shown to affect compressive strength (Adel & Ahmed, 2015; Adel et al., 2011). Eddie (2017) has studied he use of nano silica can improve the mechanical properties and durability of high performance concrete (HPC). The allowances for the long-term creep effects in the British Standard and in the Eurocode 2 for the design of reinforced concrete columns have shown some discrepancy (Wong, 1996), while American Society for Testing and Materials International (ASTM) 157 (2009) defines concrete shrinkage test specimens in the beam form.

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The water to cement ratio influences water distribution and subsequently influences the kinetic properties of concrete, especially shrinkage and creep (Feldman, 1969). Water holds an important

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The water to cement ratio influences water distribution and subsequently influences the kinetic properties of concrete, especially shrinkage and creep (Feldman, 1969). Water holds an important role in the volume change mechanism (D'Ambrosia & Mohler, 2011). High strength concrete (HSC), HPC, and ultra-high performance concrete (UHPC) always use limited water; therefore, their deformation behavior is absolutely different from normal concrete. The absence of coarse aggregate was considered to be a key-aspect for the micro-structure and the performance of UHPC in order to reduce heterogenity between the cement matrix and the aggregate (Adel & Ahmed, 2015). The use of limited water causes not all ettringite to form at the plastic phase. Ettringite that is formed after the plastic phase leads to early cracking.

Deformation in columns should get more attention because column failure will lead to building collapse. Besides deformation by the hydration process, the effect of column shortening is a major consideration in the design and construction of tall buildings, especially in the concrete and composite structural system. Column shortening occurs because of applied load. Many researchers have been interested in studying deformation. Lampropoulos and Dritsos (2011) have studied the shrinkage behavior of concrete columns with compressive strengths of 24.7 MPa – 30.6 MPa subjected to monotonic and cyclic loading. The creep observation of HSC columns confined by fibre-reinforcements has been published (Ma & Wang, 2010). The creep behavior of HSC is similar to normal strength concrete, where the creep rate decreases as time increases (Mertol et al., 2010). This statement fits with the shrinkage formula in American Concrete Institute 209R (ACI 209R) (1992). Non-uniform shrinkage and creep in slender concrete frames and columns has been observed (Kawano & Warner, 1997).

Although the pattern of deformation in many types of structure between HSC and normal concrete are similar, the deformation value varies with the types of structure. The hydration process in columns occurs under pressure conditions from their own weight, making column deformation different from deformation in the beam. Neville (2012) also states that deformation, deflection, strain, and stress distribution are also affected by the type of structure. Until now, there has been no comparison between the long-term deformation of beams and columns, especially for high performance concrete. Based on these explanations, beam and column deformation research is needed.

The purpose of this study was to find the cause of the differences in deformation between beams