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**Analisis Perbandingan Kebutuhan Beton Bertulang Berdasarkan Pendekatan Level of Development (LOD)
100, 300, dan 400 pada Gedung Pendidikan di Semarang**
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ABSTRAK

Pekerjaan struktur beton bertulang menyerap porsi anggaran yang besar dalam proyek konstruksi gedung bertingkat, sehingga perhitungan kebutuhan material beton dan baja tulangan perlu dilakukan secara akurat sejak tahap perencanaan. Namun, terdapat kesenjangan antara estimasi konseptual awal, perencanaan (*Detail Engineering Design*), dan pelaksanaan (*shop drawing*), di mana kajian perbandingan bertingkat antar-pendekatan *Level of Development* (LOD) secara rinci pada tiap tipe elemen struktur masih terbatas. Penelitian ini bertujuan untuk menghitung dan menganalisis perbandingan kebutuhan beton bertulang serta estimasi biaya material berdasarkan pendekatan LOD 100, LOD 300, dan LOD 400 pada gedung pendidikan di Semarang, serta mengidentifikasi faktor-faktor yang menyebabkan perbedaan kuantitas tersebut.

Penelitian ini mengambil studi kasus Pembangunan Gedung Twin Tower Universitas Diponegoro Semarang pada Tower 1 (lantai dasar hingga lantai 7), yang mencakup elemen *pile cap, bored pile*, kolom, balok, pelat lantai, dan *shear wall*. Data sekunder meliputi dokumen gambar DED, *shop drawing*, serta regulasi Analisis Harga Satuan Pekerjaan (AHSP) PUPR dan Peraturan Wali Kota Semarang. Data primer diperoleh dari ekstraksi *Quantity Take-Off* (QTO) pemodelan 3D menggunakan perangkat lunak Autodesk Revit. Metode analisis dilakukan melalui tiga pendekatan, yaitu LOD 100 dihitung secara konseptual makro berdasarkan luas bangunan dan rasio acuan, LOD 300 dihitung manual berdasarkan gambar DED, serta LOD 400 dimodelkan melalui BIM berbasis *shop drawing.*

Penelitian ini mengungkapkan bahwa kebutuhan material beton bertulang cenderung meningkat seiring dengan semakin tingginya tingkat LOD dan detail informasi yang disajikan. Berdasarkan hasil ekstraksi data, pendekatan LOD 300 memperoleh volume beton sebesar 6.779,54 m^3 dan baja tulangan sebesar 942.249,75 kg, sedangkan pada LOD 400 diperoleh volume beton sebesar 6.788,75 m^3 dan baja tulangan sebesar 945.198,86 kg (dengan selisih total bangunan sebesar +0,14% beton dan +0,31% baja tulangan). Meskipun selisih akumulasi pada skala total bangunan relatif kecil, perbedaan kebutuhan material bersifat *element-dependent* atau bervariasi tergantung pada karakteristik dan tipe elemen struktur masing-masing. Perbedaan kuantitas material tersebut dipengaruhi oleh dua faktor utama, yaitu perubahan desain dari gambar DED ke *shop drawing* serta kemampuan pemodelan BIM LOD 400 dalam mengeliminasi tumpang-tindih beton (*clash detection*).

Kata kunci: *Level of Development*, beton bertulang, *Building Information Modeling*, estimasi biaya, *quantity take-off*

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ABSTRACT

Reinforced concrete structural work absorbs a large portion of the budget in high-rise building construction projects, making the accurate calculation of concrete and reinforcing steel material requirements essential from the planning stage. However, there is a gap between initial conceptual estimates, planning (Detail Engineering Design / DED), and execution (shop drawings), where detailed multi-tier comparative studies among Level of Development (LOD) approaches for each type of structural element remain limited. This study aims to calculate and analyze the comparison of reinforced concrete requirements and material cost estimates based on LOD 100, LOD 300, and LOD 400 approaches for an educational building in Semarang, as well as to identify the factors causing these quantity discrepancies.

This study takes a case study of the Twin Tower Building Construction of Diponegoro University Semarang on Tower 1 (ground floor to 7th floor), which encompasses pile cap, bored pile, column, beam, floor slab, and shear wall elements. Secondary data include DED drawings, shop drawings, as well as regulations from the Ministry of Public Works and Housing (PUPR) Work Unit Price Analysis (AHSP) and the Semarang Mayor Regulation. Primary data were obtained from the Quantity Take-Off (QTO) extraction of 3D modeling using Autodesk Revit software. The analysis method was carried out through three approaches: LOD 100 calculated conceptually on a macro level based on building area and reference ratios, LOD 300 calculated manually based on DED drawings, and LOD 400 modeled via BIM based on shop drawings.

This study reveals that reinforced concrete material requirements tend to increase along with higher LOD levels and the level of information detail presented. Based on the data extraction results, the LOD 300 approach obtained a concrete volume of 6,779.54 m^3 and reinforcing steel of 942,249.75 kg, whereas LOD 400 obtained a concrete volume of 6,788.75 m^3 and reinforcing steel of 945,198.86 kg (with a total building difference of +0.14% for concrete and +0.31% for reinforcing steel). Although the accumulated discrepancy at the total building scale is relatively small, the differences in material requirements are element-dependent or vary depending on the characteristics and type of each structural element. The differences in material quantities are influenced by two main factors: design changes from DED to shop drawings and the capability of LOD 400 BIM modeling in eliminating concrete overlaps (clash detection).

Keywords: Level of Development, reinforced concrete, Building Information Modeling, cost estimation, quantity take-off