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Optimasi Waste Baja Tulangan Berbasis BIM Cubicost, First Fit Decreasing, dan Cutting Optimization Pro (Studi Kasus: Proyek The Aloon-Aloon)
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INTISARI

Sejumlah studi kasus di Indonesia mengindikasikan volume sisa material (*waste*) konstruksi gedung bertingkat mencapai rentang 2,9% hingga 12,5%, dengan kontribusi limbah baja tulangan mendominasi sebesar 34,68% dan menyerap anggaran hingga 20% dari total biaya proyek. Pengelolaan *waste* yang buruk mengakibatkan inefisiensi material, kerusakan lingkungan, dan pembengkakan biaya konstruksi. Penelitian ini bertujuan untuk menganalisis kuantitas kebutuhan baja tulangan hasil pemodelan *Building Information Modeling* (BIM) Cubicost TRB, serta membandingkan persentase *waste* hasil optimasi pemotongan antara algoritma *First Fit Decreasing* (FFD) dan *software* Cutting Optimization Pro (COP).

Metode penelitian dilakukan secara sistematis melalui tahapan berikut. Pertama pemodelan baja tulangan melalui BIM Cubicost TRB guna mengekstrak draf *Bar Bending Schedule* (BBS) otomatis serta mengidentifikasi *waste* baja tulangan bawaan program. Kedua, data *Rebar Combination Report* dari model BIM dieksplorasi dan diekstraksi menggunakan makro VBA Excel untuk proses dekomposisi teks label, filter diameter, serta agregasi data kebutuhan bersih (*demand*). Ketiga, data bersih tersebut diuji ke dalam 12 variasi skenario pemotongan (*cutting stock problem*) *standard* dan *generational* lintas lantai serta zona menggunakan algoritma FFD dan perangkat lunak COP.

Hasil penelitian menunjukkan total *demand* bersih proyek sebesar 1.139.139,03 kg dengan rentang panjang potongan 126 mm hingga 12.000 mm. Skenario COP-G1D-SATU GEDUNG menjadi skenario paling optimal secara mutlak dengan *waste* terendah sebesar 1,33% (15.386,15 kg) dan kebutuhan fisik 85.949 batang 12 meter, mengungguli Cubicost (1,52%; 85.996 batang) dan FFD Satu Gedung (1,61%; 86.202 batang). Kesimpulannya, perluasan ruang komputasi spasial, intervensi *user-guided*, dan pemanfaatan *carry-over stock* secara *generational* terbukti konsisten meminimalkan *waste* dan pengadaan fisik baja tulangan.

Kata kunci: BIM Cubicost TRB, *Carry Over Stock*, *Cutting Stock Problem, First Fit Decreasing*, Cutting Optimization Pro.

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ABSTRACT

A number of case studies in Indonesia indicate that the volume of construction material waste in high-rise buildings reaches a range of 2.9% to 12.5%, with reinforcement steel waste dominating at 34.68% and consuming up to 20% of the total project budget. Poor waste management leads to material inefficiency, environmental damage, and construction cost overruns. This study aims to analyze the quantity of reinforcement steel requirements resulting from Building Information Modeling (BIM) Cubicost TRB, and to compare the cutting waste percentage generated by the First Fit Decreasing (FD) algorithm and Cutting Optimization Pro (COP) software.

The research method was conducted systematically through the following stages. First, visual reconstruction and gross quantity estimation of the reinforcement were performed via BIM Cubicost TRB to extract automatic Bar Bending Schedule (BBS) data and identify the program's inherent baseline waste. Second, the Rebar Combination Report data from the BIM model was explored and extracted using Excel VBA macros for label text decomposition, diameter filtering, and net requirement (demand) aggregation. Third, the clean linear input data was tested across 12 variations of standard and generational cutting scenarios (Cutting Stock Problem) across floors and zones using the FFD algorithm and COP software.

The results indicated that the total demand for the project reached 1,139,139.03 kg, with cutting lengths ranging from 126 mm to 12,000 mm. The COP-G1D-SATU GEDUNG scenario was identified as the absolute most optimal scenario, achieving the lowest waste percentage of 1.33% (15,386.15 kg) and requiring a physical demand of 85,949 units of 12-meter bars, thereby outperforming Cubicost (1.52%; 85,996 units) and FFD Single Building (1.61%; 86,202 units). In conclusion, expanding the spatial computational scope, applying user-guided interventions, and utilizing generational carry-over stock are proven to consistently minimize both waste material and the physical procurement of steel reinforcement bar..

Keywords: *BIM Cubicost TRB*, *Carry Over Stock*, *Cutting Stock Problem, First Fit Decreasing*, *Cutting Optimization Pro.*