

Kegagalan struktur lapangan olahraga terjadi akibat beban angin dan hujan lebat yang melebihi kapasitas struktur dalam menahan beban yang bekerja. Akibatnya, terjadi kerusakan elemen struktur, kerugian ekonomi, serta adanya peningkatan emisi karbon akibat pembangunan ulang bangunan. Kondisi tersebut menunjukkan pentingnya perencanaan struktur yang memenuhi persyaratan keamanan dan keberlanjutan. Perancangan ini bertujuan untuk mengusulkan desain ulang struktur baja lapangan olahraga yang memenuhi ketentuan kinerja struktur sesuai SNI 1729:2020 (Spesifikasi untuk Bangunan Gedung Baja Struktural), kemudian menganalisa biaya konstruksi antara struktur eksisting dan struktur hasil desain ulang, serta menganalisa dan membandingkan total emisi karbon yang dihasilkan dari pabrikasi material baja dan penggunaan alat berat pada pekerjaan ereksi baja struktur.

Metode perancangan dilakukan melalui pemodelan dan analisa struktur menggunakan *ETABS v22*, pemodelan 3D menggunakan *Tekla Structures 2025* untuk proses *Quantity Take-Off*, serta perhitungan emisi karbon menggunakan *Tekla Structural Designer 2025*. Teknik analisis data dilakukan dengan analisis struktur, membandingkan volume pekerjaan, Rencana Anggaran Biaya (RAB), dan total emisi karbon antara struktur eksisting dan struktur hasil desain ulang.

Hasil perancangan menunjukkan bahwa desain ulang menggunakan kombinasi profil pipa baja struktural, *Wide Flange* (WF), dan *tie rod* telah memenuhi persyaratan keamanan struktur berdasarkan evaluasi bentuk ragam, periode struktur, simpangan, efek P-delta, lendutan maksimum, serta rasio kapasitas elemen struktur sesuai SNI 1729:2020. Hasil analisis biaya menunjukkan bahwa nilai RAB struktur eksisting sebesar Rp7.445.592.999, sedangkan struktur hasil desain ulang sebesar Rp7.845.527.655 atau meningkat 5,37%. Peningkatan biaya tersebut dipengaruhi oleh adanya perubahan konfigurasi dan dimensi elemen struktur dari struktur awal. Total emisi karbon struktur eksisting dalam kilogram berat sebesar 1,873 kgCO<sub>2</sub>e/kg dan meningkat menjadi 2,106 kgCO<sub>2</sub>e/kg atau bertambah 11,10% yang diakibatkan adanya penambahan massa struktur akibat dari konfigurasi baja struktur yang berbeda. Dengan demikian, desain ulang yang diusulkan mampu meningkatkan keamanan struktur sesuai standar yang berlaku, meskipun menyebabkan peningkatan biaya konstruksi dan emisi karbon.

**Kata kunci:** Struktur baja, Desain ulang, Rancangan anggaran biaya, *Embodied carbon*, Analisa struktur.

## ABSTRACT

*The structural failure of the sports facility was caused by wind and heavy rainfall loads that exceeded the structure's load-carrying capacity. As a result, structural components were damaged, leading to economic losses and increased carbon emissions associated with the reconstruction process. This condition highlights the importance of structural design that satisfies both safety and sustainability requirements. This study aims to propose a redesign of the sports facility steel structure that complies with the structural performance requirements specified in SNI 1729:2020 (Specification for Structural Steel Buildings). Furthermore, the study analyzes the construction costs of the existing structure and the redesigned structure, as well as evaluates and compares the total carbon emissions generated from steel material fabrication and the use of heavy equipment during the steel structure erection process.*

*The design method was carried out through structural modeling and analysis using ETABS v22, 3D modeling using Tekla Structures 2025 for Quantity Take-Off purposes, and carbon emission calculation using Tekla Structural Designer 2025. Data analysis techniques included structural analysis and comparison of work volume, cost estimation (RAB), and total carbon emissions between the existing and redesigned structures.*

*The design results show that the redesign, which utilizes a combination of structural steel pipe profiles, Wide Flange (WF) sections, and tie rods, satisfies the structural safety requirements based on evaluations of mode shapes, structural periods, drift, P-delta effects, maximum deflection, and member capacity ratios in accordance with SNI 1729:2020. The cost analysis indicates that the cost estimate (RAB) of the existing structure amounts to IDR 7,445,592,999, while that of the redesigned structure amounts to IDR 7,845,527,655, representing an increase of 5.37%. This cost increase is attributed to changes in the configuration and dimensions of the structural elements compared to the original design. The total carbon emissions of the existing structure amount to 1,873 kgCO<sub>2</sub>e/kg, increasing to 2,106 kgCO<sub>2</sub>e/kg, or a rise of 11.10%, resulting from the increased structural mass due to the different steel configuration. Therefore, the proposed redesign successfully improves structural safety in accordance with applicable standards, although it results in increased construction costs and carbon emissions.*

**Keywords:** Steel structure, Redesign, Cost estimation, Embodied carbon, Structural analysis.