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Paper Title: Impact of Appraisal and Cost Engineering on Sustainable Assets and Facility Management

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Abstract:

Facilities are important assets of a Nation and are therefore provided with basic engineering specifications necessary for functional performance. The aim of the investigation is the impact of appraisal and cost engineering on sustainable assets and facility management, which involve identifying the importance facility management in sustaining the capacity and sustaining performance over anticipated period, which was conducted according to the procedures provided in ISO 41000 series, a globally recognized international standards that regulates and streamline facility management. The paper further enumerated factors that affects facility performance and methods of preventing occurrence of breakdown of services, by evaluating depreciation in value as components of loss in value associated with energy loss in the engineering systems which was analyse by enumerating the followings, value proposition, value analysis, value depreciation, and value sustainability. Failure mechanism was also discussed involve the effect of applied load leading to stress, strain, fatigue and fracture or collapse, which also involve processes, that is, degradation, wear and tear, deterioration, deformation. In conclusion, it was determined that facilities are important for engineering activities and productions that consume energy leading to reduction over time. Therefore, adequate monitoring, routine inspection and maintenance are required to provide information on system's performance and reliability.

Key words: Facility management, Assets, ISO 41000, Value analysis, Maintenance

1.0: Introduction:

Assets are tangible or intangible items of value owned or controlled by individual, business or entity that have monetary worth and/or provides future economic benefit (Foss and Foss, 2001). They are often classified as Physical (tangible) assets, financial assets and Intangible assets. Tangible assets are physical items with measurable monetary value. Example includes real estate, vehicles, machinery, and inventory etc (Dowries and Goodman, 2003). Financial assets are abstract items of value representing an ownership claim or obligation which include stocks, bonds and bank deposits etc. Intangible assets are non-physical resources that provide an economic advantage or marketability, including patents, copyrights, trademarks and goodwill (Victor et al, 2024). Engineering facilities (Finch and Zhang, 2018) are the infrastructures, machines, equipment, produced through engineering design specifications to fulfil a specific purpose (Barett and Finch (2014). Facilities are classified as follows,

Infrastructures – buildings, bridges, highway, refineries, power supply network etc

. Vehicles; cars, lorry, heavy duty vehicles, ships, aircraft, military vehicles etc

. Machines and Industrial plant

. Manufacturing industry

1.1: Process engineering is a field of study that focused on the development and optimization of industrial processes. It consists of understanding of the fundamental principles and law of nature to allow transformation of raw materials and energy into useful products to society and the Nation at large. Industrial process is a systematic set of mechanical, physical, electrical or chemical procedures used to convert raw materials into finished and valuable goods using mechanical equipment, energy and labour (Okolie et al, 2020). It involves heavy industries (ie, automobile, aerospace, steel manufacturing) and light industries (ie, electronics, textiles, food processing etc). These large-scale operations prioritize efficiency, scalability and precision thereby forming the backbone of global manufacturing economy.

Industrial manufacturing (Groover, 2010), are broadly classified into several operational types as follow,

Continuous processing; materials flow constantly through the system (eg, chemical production, oil refinery etc)

Batch processing; materials are produced in district, set quantities (eg, pharmaceuticals, brewing, food manufacturing etc)

Discrete processing; distinct, individual items are built sequentially (eg, smart phones, automobile assembly, electronics etc)

1.2: Facility Engineering is the multi-discipline field focused on design, construction and maintenance of physical infrastructure. It bridges multiple engineering disciplines to optimization of facility operations, reducing operating costs and ensure that built environment are safe, sustainable and complaint with all technical regulations (Finch and Zhang, 2014). FE covers broad operational lifecycle, which include the followings

Operation and maintenance

Infrastructure design

Asset management

Safety complaint etc

2.0: Assets and **Facilities Management**

Facility management is coordinated efforts in management of an organization's buildings, infrastructures, and industry and the support services required to keep them functional, safe and effective for operations and occupants (Amaratunga et al, 2000). Scope of facilities management varies by organization and sector (Dubem et al, 2012) and usually involve the following process,

Engineering facilities → Functional use → Reduced performance over time,

and during operations, Facility management → improve performance

International standards for facilities management include the ISO 41000 series, such as

ISO 41001; Management system standard for facility management

ISO 41011; Definition of key terminology

The ISO 41001:2018, specifies requirements for facility management system, and ISO 41011: 2024, defines facility management as an organizational function which integrates people, place and process within built environment with the purpose of improving the quality of life of people and the productivity. Similarly, ISO/TR 41013:2017, provides additional context on the scope, key concepts and benefits of facility management and the use of ISO 41011 terminology.

2.1: Value Proposition; Value proposition, is a concise statement that explains why a customer choose a product or service, highlighting its unique benefits. It acts as a promise of value to the target market, focusing on tangible results and specific characteristics (Jonker and Carvalho, 2015). Performance is basic parameter in analysing benefits and productivity of facilities or assets and defined as the ratio of output to the input. Values usually are proposed and achieved in engineering materials, products and processes through design specifications and engineering standards that described the limits below which the engineering system will not perform or function adequately (Amaratunga et al, 2000). Value analysis is a systematic, function focused process designed to improve the value of products, service or projects by optimizing the balance between functionality and cost. It aims to reduce unnecessary expenses while maintaining or improving quality, performance and reliability. It determines the present worth with respect to associated quality, functionality and reliability. It is an important tool in decision making evaluating the significant and worth of a facility, such as establishing the productivity and to determine if a facility should be repaired, rehabilitated or totally replaced.

Value = function/cost

Indicating that value is directly proportional to function (ie, performance), and that increase in value will result in good performance while a value decrease will give a decrease in performance thereby necessitating facility management procedures.

2.2: Value Depreciation; Depreciation in value involve reduction in an asset worth overtime due to wear, tear or obsolescence, representing the expense of using the asset. Value depreciation formula measures how an asset's worth decreases over time period. The most common approach is the straight-line method, which spreads the cost evenly and defined as follows.

Annual depreciation = (Asset cost – salvage value)/useful life

Salvage value – the estimated resale or scrap value of an asset at the end of its useful life, representing the amount a company expects to recover

Engineering facilities are used for activities that consumes energy, with reduction in value due to work activity over period of time that directly affects the system's performance, that enables functioning at reduced energy level (eg, value depreciation)

2.3: Value Sustainability: Depreciation in value of facilities over time necessitates routine inspection and maintenance to sustain the ability to perform adequately. Sustainability is the ability to maintain or improve availability of resources over the long term and can also be defined as meeting present needs without compromising future generations by balancing environmental, social and economics need and ensuring stability. Value sustainability is a strategic approach that integrates environmental, social, and economic factors into business models to generate long-term value for all stakeholders, rather than focusing solely on the short-term. In facilities management value sustainability involve all activities implemented to ensure reliability and performance, which include, facility inspection, maintenance and rehabilitation.

3.0: Engineering Failure Mechanisms

Failure mechanisms are the events that occur during functional used caused by facility's response to continuous load application and functional requirements.

Ie, Load application → Stress and strain → deformation → Fatigue → Fracture/collapse

Failure process entails the following activities associated with loss of energy (strength), which negatively affects performance

Degradation, wear and tear

Deterioration; Corrosion, oxidation and reduction etc

Deformation of structural components

Engineering failure analysis is the systematic forensic process used to determine and evaluate failure of materials, components and systems. It involves determination of the root causes for the purpose of providing possible solutions

Physical failure (eg, deformation, fatigue etc)

Chemical failure (eg, Corrosion)

Systemic failure (eg, design flaws, materials etc)

3.1: Failure Mode and Effects Analysis (FMEA); A Structured, proactive risk assessment tool used to identify potential failures in a product, process or system, their causes and consequences. The goal is to prioritize and mitigate risks before resulting in defects, downtime or harm. FMEA involves answering four fundamental questions on the state of a system or process, as follows

Failure mode; specific way in which a component, system or process fail to perform its intended function

Failure causes; applied force, moisture and other environmental factor etc

Failure effects; The consequence of failure as a result of reduced energy, loss of integrity and collapse

Failure prevention; Implementing systematic analysis and maintenance to avoid costly downtime, extend asset lifespans and ensure operational continuity of facilities. Essential component of failure prevention is quality assurance and testing which entails establishing rigorous checks to prevent failure during the development lifecycle, ensuring materials and operational environment meet exact specifications

3.2: RPN); a metric used in failure mode and effects analysis to quantify and prioritize potential risks. It calculates the critical level of a failure mode by multiplying three core factors associated with a failure mode, ie, Severity (S), Occurrence (O) and Detection (D). Severity describes the degree of intensity or harmfulness of undesirable event, Occurrence is the commencement of an unexpected event, an incident etc while Detection is the act of identifying, discovering etc, which sometime is considered not important in physical object performance assessment.

RPN = Occurrence (O) x Detection (D) x Severity (S) = OxDxS

= O x S since D has been measured with D

Each factor is typically rated on a standardized scale from 1 to 10, Therefore, RPN will produce a total score between 1 and 100.

While specific action threshold vary by organization, a typical industry risk evaluation breaks down as follows

1 – 4 (ie, Low risk); acceptable risk, and can be monitored periodically

5 – 10 (ie, Moderate risk); corrective action may be required

11-20 ie, High risk); mitigation action is required

. > 20 (Critical risk); immediate corrective action required to alter design, process or controls

4.0: Engineering Appraisals of Facilities

Engineering appraisal is the process of evaluating the processes involved in a project or program or the viability (Goodman, 1988 and David & Roland, 2006), it often involves comparing various options and alternatives using economic appraisal or some other decision-making technique. For a project to be successful, it should be objectively appraised during feasibility study, which involve principal dimensions, technical, economic, financial and social implications to establish justification for the implementation (Solomon, 1970), while appraisal is the process of evaluating and assessing profitability or otherwise of a project feasibility. Economic impact analysis (EIA), examines the effect of an event on the economy in a specified community, ranging from a single neighbourhood to the global world. It usually measures change in business revenue, business profits, personal wages etc and typically measures or estimates the change in economic activity between two scenarios, one assuming the economic events occurs, and one assuming it does not occur (or, the counterfactual case). Production function provides the relationship between quantities inputs and quantities output including the enabling technology. It is commonly used to specify the maximum output obtainable from a given set of inputs which therefore describes a boundary or frontier representing the limit of output obtainable from each feasible combination of inputs.

Alternatively, a production function is defined as the specification of minimum input requirements to produce designated quantities of output of certain standard or quality. Productivity: is the efficiency of production of goods and services expressed by some measure. Measurement of productivity is often expressed as a ratio of an aggregate output to a single input or aggregate input used in production process, ie, output per unit input over specific period of time

Ie, Productivity = Output/Input

Productivity with respect to one class of input or factor is known as partial productivity and when multiple inputs are used to determine the productivity it is called multi-factor productivity (MFP) , also if the inputs specifically are labour and capital and the outputs are value added, the measure is known as total factor productivity (TFP). A valid measurement of total productivity requires consideration of all production inputs. If an input is omitted or not considered, it means the input can be used unlimitedly in production without any impact on accounting results. Total productivity includes all production inputs, therefore are used as integrated variable when explaining income formation of the production process. Facilities with depreciated value (or, quality) cannot produce effectively but rather with decline productivity or productive inefficiency, with economy below the expected production possibility frontier occurring because the productive inputs (physical labour and capital) are underutilized, that is, these inputs are allocated at inappropriate combinations. The process of engineering appraisal involves performance monitoring, inspection and evaluation of the present state of facilities and also to suggest possibilities of ensuring continuous functionality and reliability of the system which sometimes could entail preventive maintenance, rehabilitation or reconstruction if the present state, significantly affects the reliability and performance. Project cost management (PCM) is a method which aims at ensuring a project is completed within the approved budget, it involves several project management activities including, design, estimating, job controls, project tasks identification and evaluation, scheduling, and accounting (PMBOK, 2021). It uses technology to measure cost and productivity through the life cycle of the project, which commence with estimating, a vital tool in PCM, historical cost data, used to accurately plan all aspects of the project and as project progresses, the project control uses data from estimates and information collected from market trends to measure cost and production in the project.

5.0: Conclusion

Engineering facilities are socio-economic assets necessary for development of a Nation and therefore must be provided with required engineering specifications to enable adequate performance through the lifecycle. Common facilities include, Bridges, Building, Vehicles, Industry etc.

Facility management is the coordinated effort in management of assets to keep them functional, safe and effective. Basic procedures in facility management system are provided in ISO 41000 series.

Productivity and efficiency are important parameters used in evaluation of production system and measured as ratio of output per unit input, which can also be used in assessment of

resource utilization in production which is effective when the ratio is greater than one (> 1) indicating profitable investment

Facilities are used for activities that consume energy, leading to reduction in value (ie, depreciation) over time, and which directly affect the systems performance and reliability. Adequate monitoring and routine inspection provide information on the reliability and state of a facility, (ie, $0 < R(t) < 1$)

Failure mechanism are events that occur during functional use, caused by the facility response to load application and negatively affect reliability and performance. Reliability involves failure prevention, by implementing systematic analysis and maintenance to ensure operational continuity of facilities.

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