GRAPHICAL OPTIMIZATION OF BUILDABILITY IN BUILDING CONSTRUCTION: A CASE STUDY OF PRECONSTRUCTION PHASE

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Abstract

The aim of this study is to assess the factors affecting buildability in building construction. The use of IDEF and UML diagrams were considered as the best way of evaluating all the construction processes with a view to determining buildability of the project. The study concludes that construction projects entail multi-disciplinary construction processes with defined critical paths, especially at the preconstruction phase for buildability to be achieved.

1.0 Introduction

A construction process is a series of strategized steps, or phases usually carried out in order to achieve a set of desired construction development objectives. These steps or phases vary with different types and or complexities of projects. They are highly professional in nature, spanning through various relevant disciplines in the built environment to ensure buildability. Two major accredited formats that are employed in the construction industry include the Royal Institute of British Architects (RIBA) plan of work (2020) and the Chartered Institute of Building (CIOB) code of practice for project management. These processes are done at both the pre-construction and post-construction frameworks (RIBA, 2020). The RIBA plan of work (2020) focuses on preparation and briefing, concept design, spatial coordination and technical design at the preconstruction phase while the Chartered Institute of Building (CIOB) code of practice for project management inculcates strategic planning, detailed programming and monitoring, resource allocation and effective risk management as well as the use of building information modeling at all stages to achieve internationalization of construction projects (CIOB, 2020).

In all cases, a drive for sustainability is desired. Construction processes are not easy tasks, especially in tall buildings and require assisting tools. For ease of preparation, consideration and analysis of these processes, integrated definition (IDEF) is used as a graphical tool for simulation of flow of activities on construction projects. According to Ghamari, Hasvanvand & Tabrizi (2014),

IDEFO is used to model decisions, actions and activities of an organization or system. IDEF ranges from IDEFO to IDEF14, depending on the construction phase and activity. IDEF is used to enhance information flow, effective data modeling, simulation, design and analysis of data. For the purpose of this study, some specified IDEF diagrams will be used for clarity and functional purposes to establish factors affecting buildability in building construction. The factors that affect buildability are as outlined and discussed below:

3.1.1 Preparation and Briefing

Business meetings, usually between the architects and the developer yield some initial mental concepts or briefs that are translated to drawings and developed for clarity and effective communication. The architects, quantity surveyors and other relevant professionals carry out feasibility studies to determine how feasible the construction would be, in terms of function, aesthetics, economy and sustainability. When the project is considered to be feasible, some risk assessments, including planning risks, are done. Specific programmes and procurement strategies are also carried out to ensure availability of adequate materials and labour. The criteria considered in the procurement strategy are in line with Rathour (2017), "Time/ certainty and early completion, certainty of cost, flexibility, price competition, complexity, quality, responsibility and risk." (Figs 1 and 2)

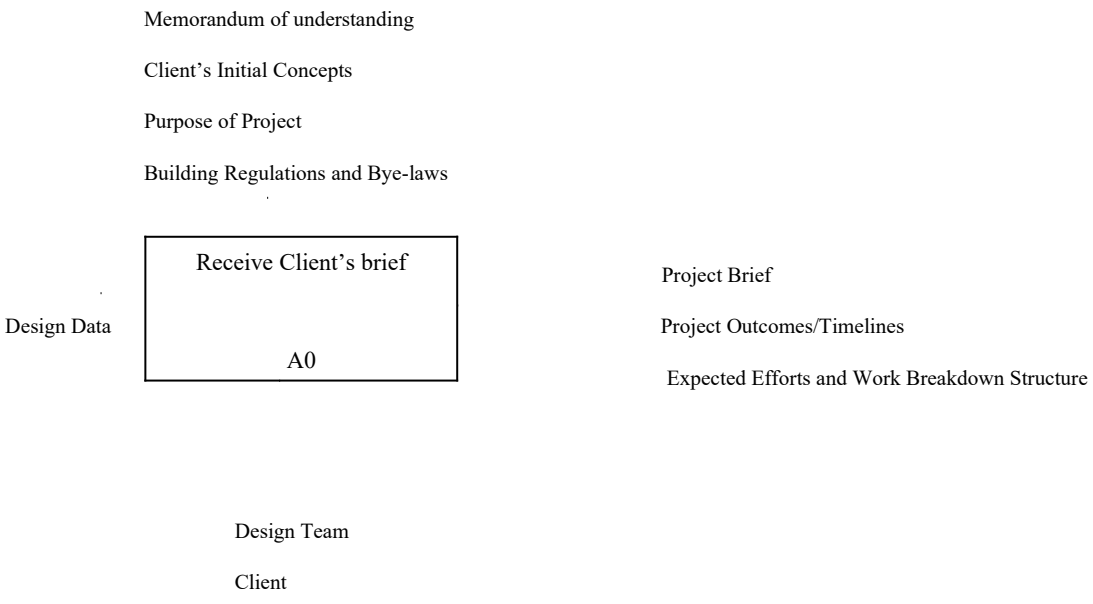

Figure 1: IDEFO diagram for preparation and briefing of a Project (Researchers' fieldwork, 2023)

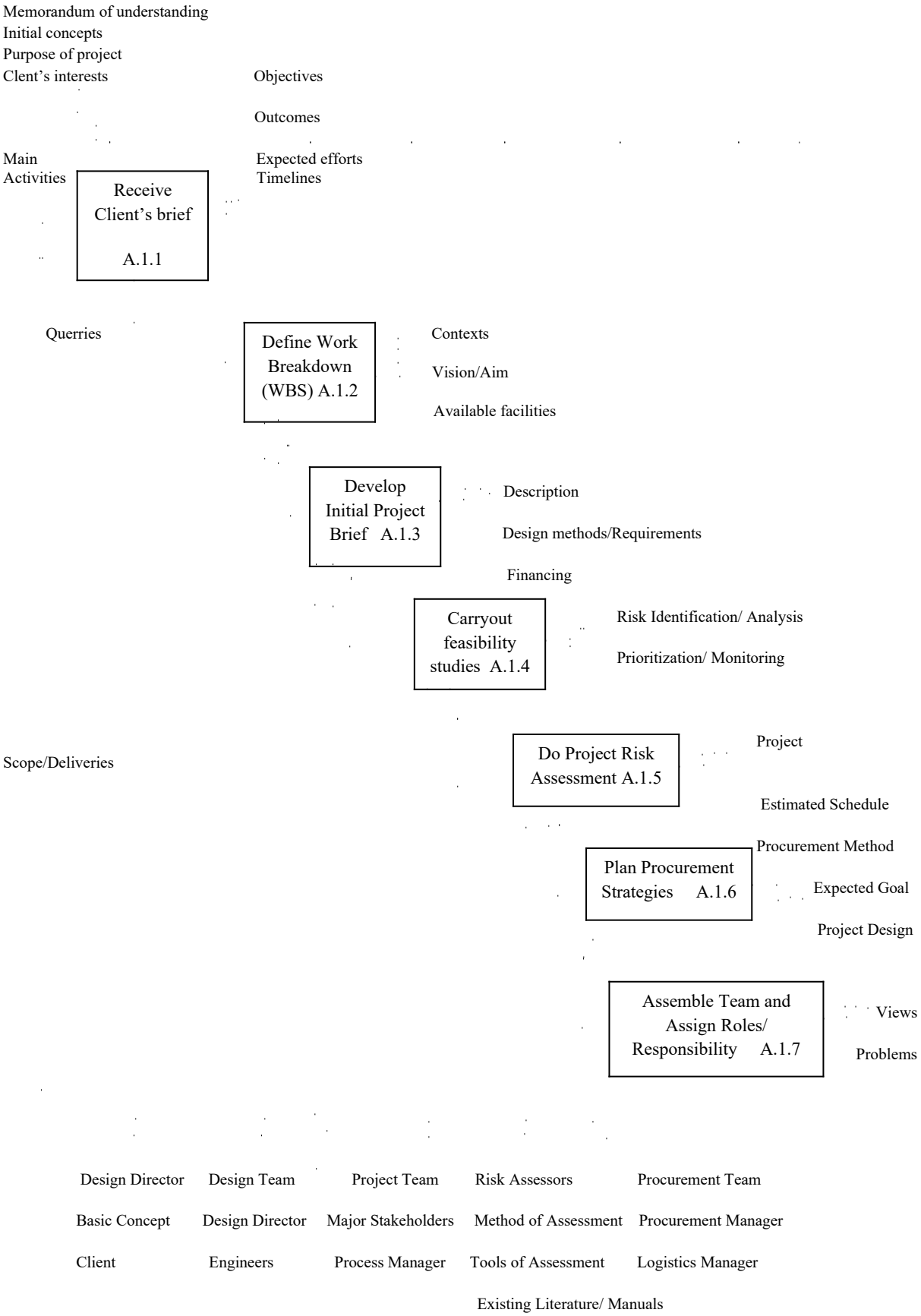

Figure 2: IDEF1 diagram for preparation and briefing of a Project (Researcher's fieldwork, 2023)

3.1.2 Concept Design

The architects' initial response to the developer's requirements for the project is a concept design. This marks the first real design step and facilitates the development and/or detailing of the design. This initial real design is carried out in line with standard, relevant specifications; schedules of accommodation; strategies of getting approval of plans from the building approval/ regulation authorities; cost plan; procurement options; programmes for consistent phase-flow of the construction process; buildability; logistics for construction; and feasibility of attaining the project brief.

The architects receive briefs from the developer and a work breakdown structure (WBS) is carried out after the endorsement of the initial contract documents/forms. The work breakdown structure could also be achieved and initial project brief developed directly after the receipt of the brief. However, for an effective work breakdown structure (WBS), relevant forms are employed (Figure 2).

Upon a successful development of the critical project brief, cost factors are identified and cost analysis requirements taken into consideration to produce a functional and reliable feasibility studies, following professional decision criteria. Both new and old components of cost data will be inputted to achieve a good plan /procurement strategy. Alternatively, once a feasibility study is done, a project risk assessment is done using web-based tools and building information models. According to Diaz (2016), building information modeling involves all information about construction, design, building management and renovation. In the preparation of a functional procurement plan, 'what-if' analysis forms and cost model computations will be used to address uncertainties. After planning procurement strategies, the project team members will be assembled for the assignment of their expected roles and responsibilities towards achieving the development of the project.

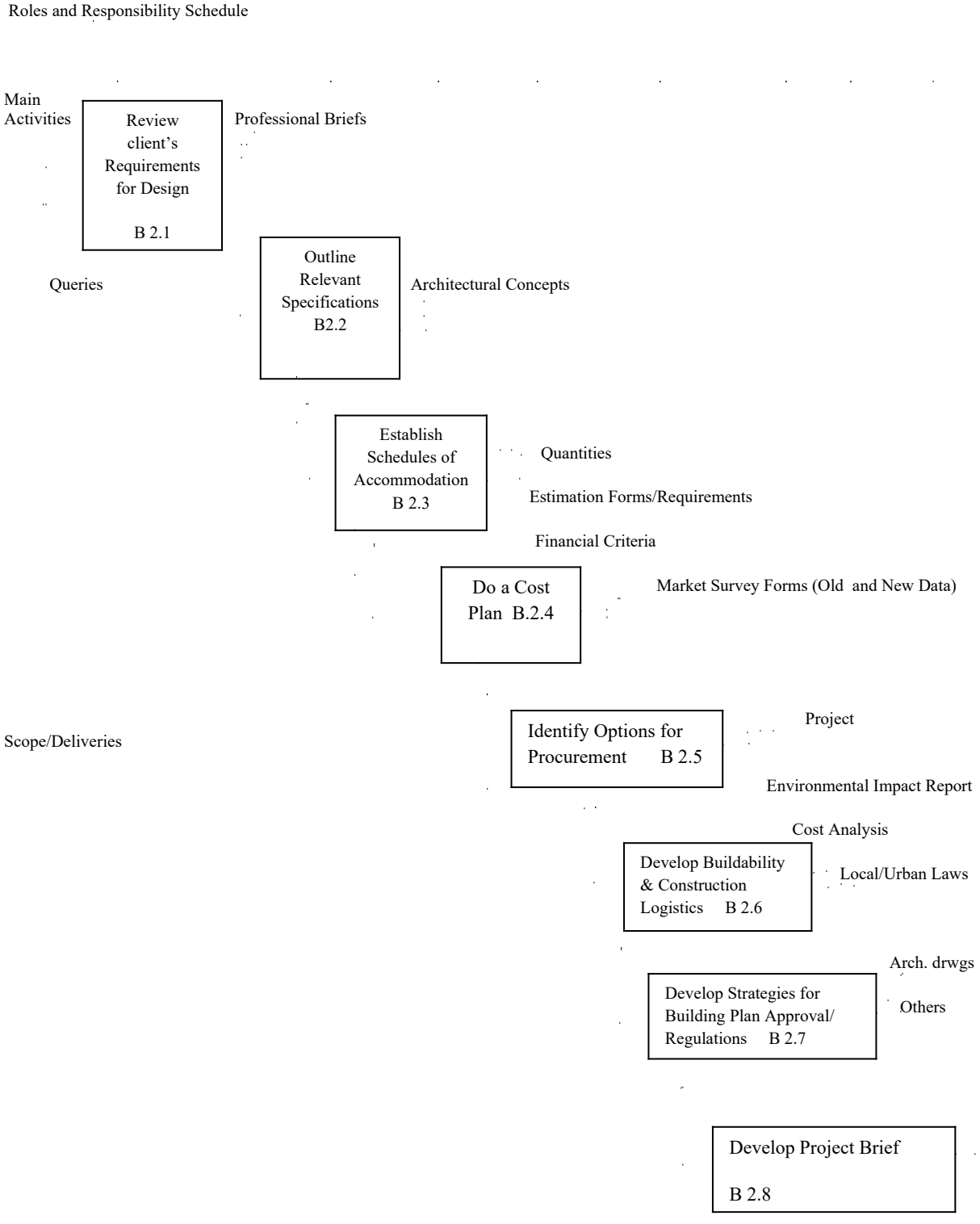

Figure 3: IDEF2 diagram for concept design of a Project (Researchers' fieldwork, 2023)

With reference to figure 3, above, once roles and responsibilities are established in the preparation and briefing stage, the different professionals will outline relevant specifications through the provision of their own briefs in line with the reviewed client's requirement for design. Architectural schedules of accommodation will be established using relevant architectural concepts. Thereafter, quantity surveyors will do a cost plan using costing/estimating forms and BIM. Quantity take-offs using BIM will be adopted considering various alternatives in the project life cycle. This agrees with Gomez-Romeo et al (2015) on building information modeling. Therefore, options for procurement will be identified via market surveys and comparing old and new data.

Employing structural integrity, environmental impact assessment and cost analysis, buildability and construction logistics will be developed. Local/zoning urban planning policies and laws will be used to develop strategies for building plan approval/regulations before the project brief is developed by the various professionals.

3.1.3 Spatial Coordination

Information from schedules of accommodation as contained in the developed project brief will be used to establish spaces. Figure 3, below, shows the IDEFO diagram for spatial coordination of the project. From the schedule of accommodation obtained in the second phase of the construction process, structural spaces will be identified. These structural spaces will be used to create grids and risers while balancing both horizontal and vertical spatial requirements. Structural detailing and BIM are other tools usually employed.

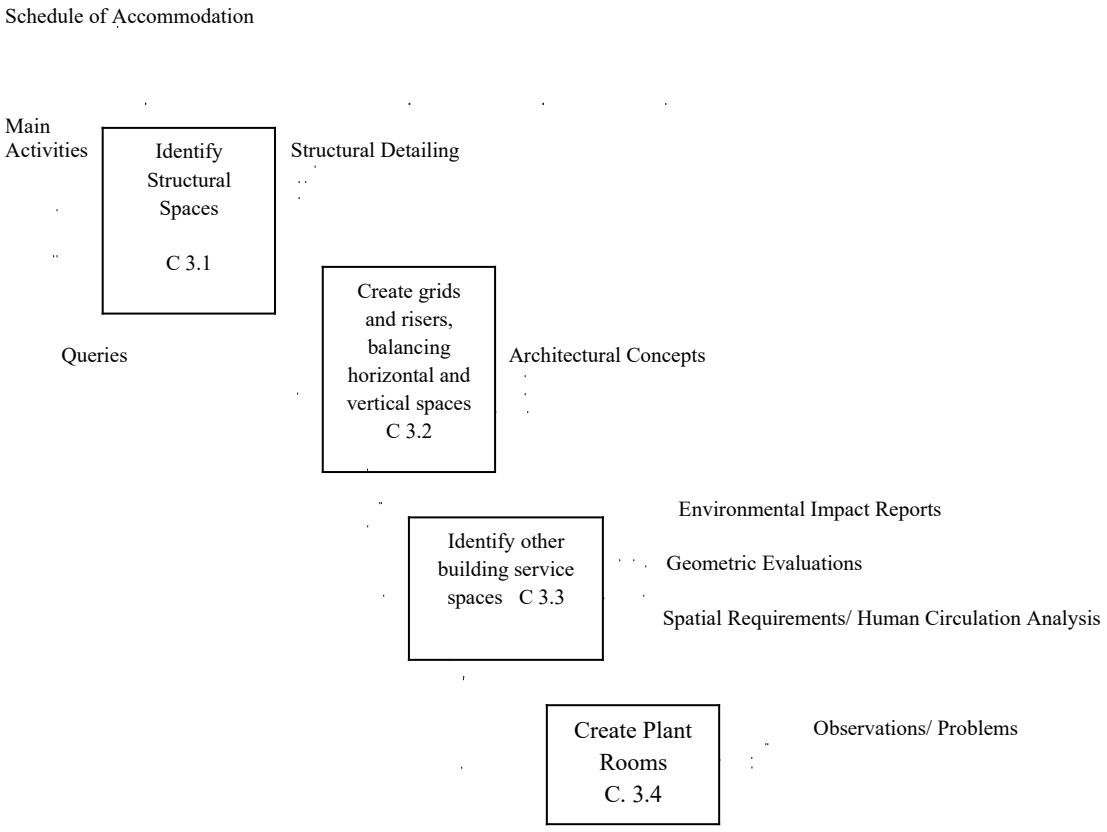

Figure 4: IDEF2 diagram for spatial coordination of a Project (Researchers' fieldwork, 2023)

3.1.4 Technical Design

The project entails the development of the design brief using adequate details. The aim of the process is to establish effective technical communication and coordination for the use of the contractors and their construction supply chain. Specific objectives will include establishing the working drawings (structural, architectural, electrical and mechanical designs) considering the feasibility of other factors or stages.

Technical design of the project is a combination of well-detailed structural, architectural, electrical and mechanical drawings employing standard specifications while taking the feasibility studies and spatial coordination into consideration.

3.2 Selected sub-processes at the preconstruction phase

The two sub-processes that are selected at the preconstruction phase are:

a. Planning procurement strategies and
b. Developing buildability and construction logistics

3.2.1 Planning procurement strategies

In the planning of procurement strategies, the following stakeholders will be involved:

a. The client
b. The main contractor
c. Project sponsors
d. Financial bodies
e. Insurers
f. Designers
g. Sub-contractors
h. Suppliers
i. Purchasing department employees

For the purpose of carrying out an activity analysis using UML diagrams, the purchasing / procurement department is considered. The major responsibilities of the department include buying products and services; managing procurement processes; maintaining supplier relationships (supply chain engagements) and ethics; sustaining business/client's goals and objectives; policy an budget management; breaking down projects into packages; determining types of engagement model-risk allocation and management responsibility; selecting appropriate commercial models (BIM); determination of timelines and milestones; establishing probity requirements; other operations and logistics.

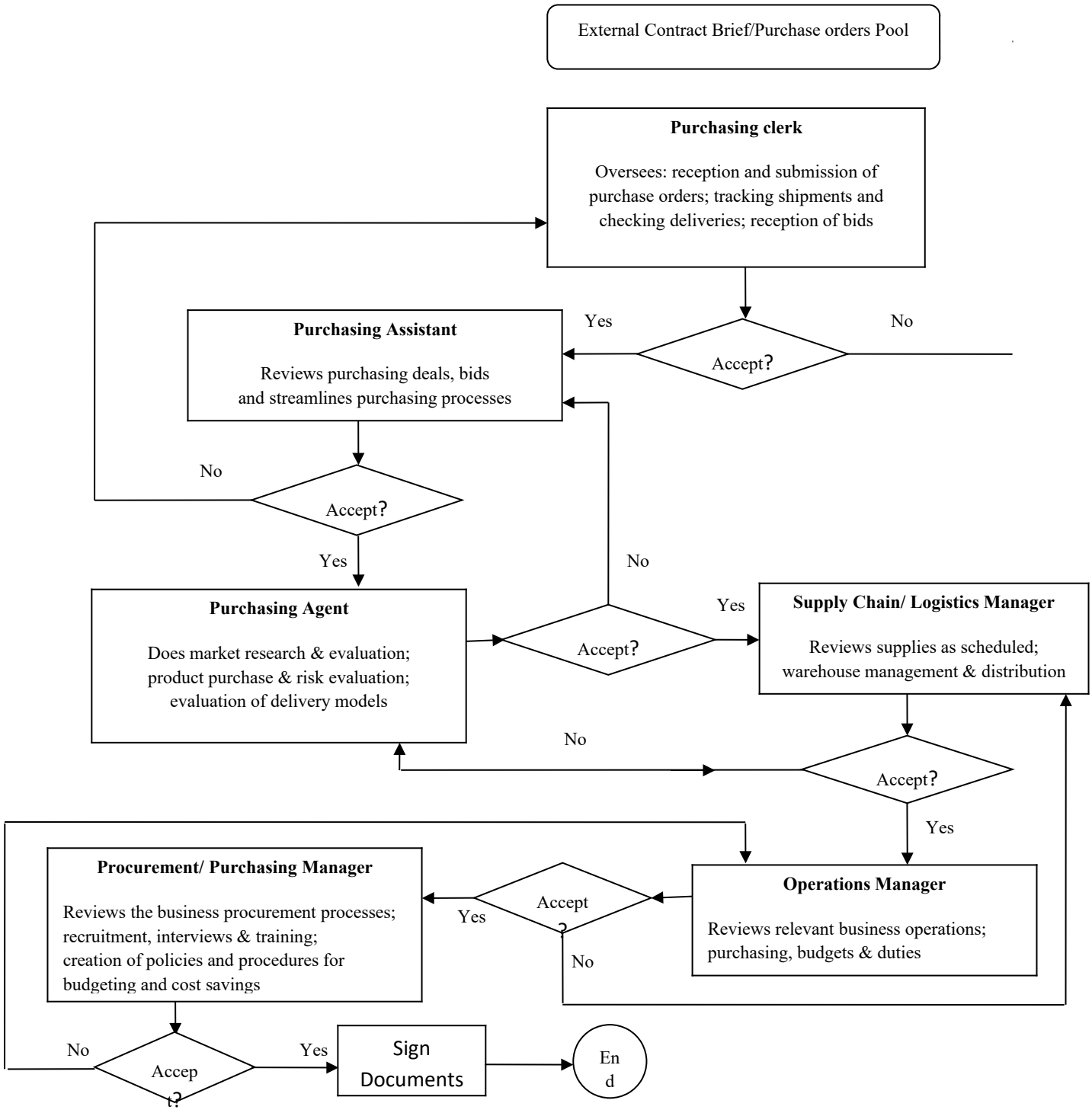

Figure 5: UML diagram for procurement department of the Project (Researchers' fieldwork, 2023)

From figure 5, above, the UML activity diagram shows the relationships between the day-to-day activities/ responsibilities of the staff of the

procurement department of the project. The employees considered are: the purchasing clerk, purchasing assistant, purchasing agent, supply chain manager, operations manager and the procurement manager. The activities span across project objectives; procurement requirements; timelines and milestones; risk evaluation; evaluation of delivery models; staff recruitment and training; staff welfare and general management of materials and labour.

3.2.2 Developing buildability and construction logistics

Buildability of construction projects entails the application of selected strategies to achieve project objectives. Some of these strategies for the tall buildings include procurement strategy; environmental strategy; vertical transportation strategy and design. To have an effective procurement strategy, procurement of materials and labour that would reduce construction times, give early start on site, phased completion and occupation is advocated. Pre-fabricated components will be majorly employed to achieve this objective in tall buildings. LEED methods will also be employed to enhance green construction while vertical transportation optimally balanced quality, quantity of lift services and capital costs of the lifts, loss of revenue earnings, tenable space and plant rooms in accordance with the findings of Wong et al. (2011).

Design also affects the buildability of a project. According to CTBUH (2000), steel, reinforced concrete and composite are the three major structural systems used in the design of projects. However, the choice of any of these methods depends on the prevailing design requirements, objective and conditions. This is necessary for a proper integration. The integration of construction into design processes provides benefits and solutions to achieving the design goals in a cost effective and timely manner (Abbas, 2014). This reduces the negative impacts of building problems or challenges.

According to Aina (2015), the impacts of building problems on project delivery are inability of clients to get value for money spent, poor serviceability, functionality, structural instability and high risk in usage but when building attributes related to the design process are included, the impact is minimized. According to Wong et al. (2011), these attributes include site specific factors (choice and type of site and site conditions); below ground factors; weather; innovations (in sequencing of site activities, detailing, flexibility, products and sub-assemblies). Figure 6 shows a

UML activity diagram of the buildability and construction logistics of a project.

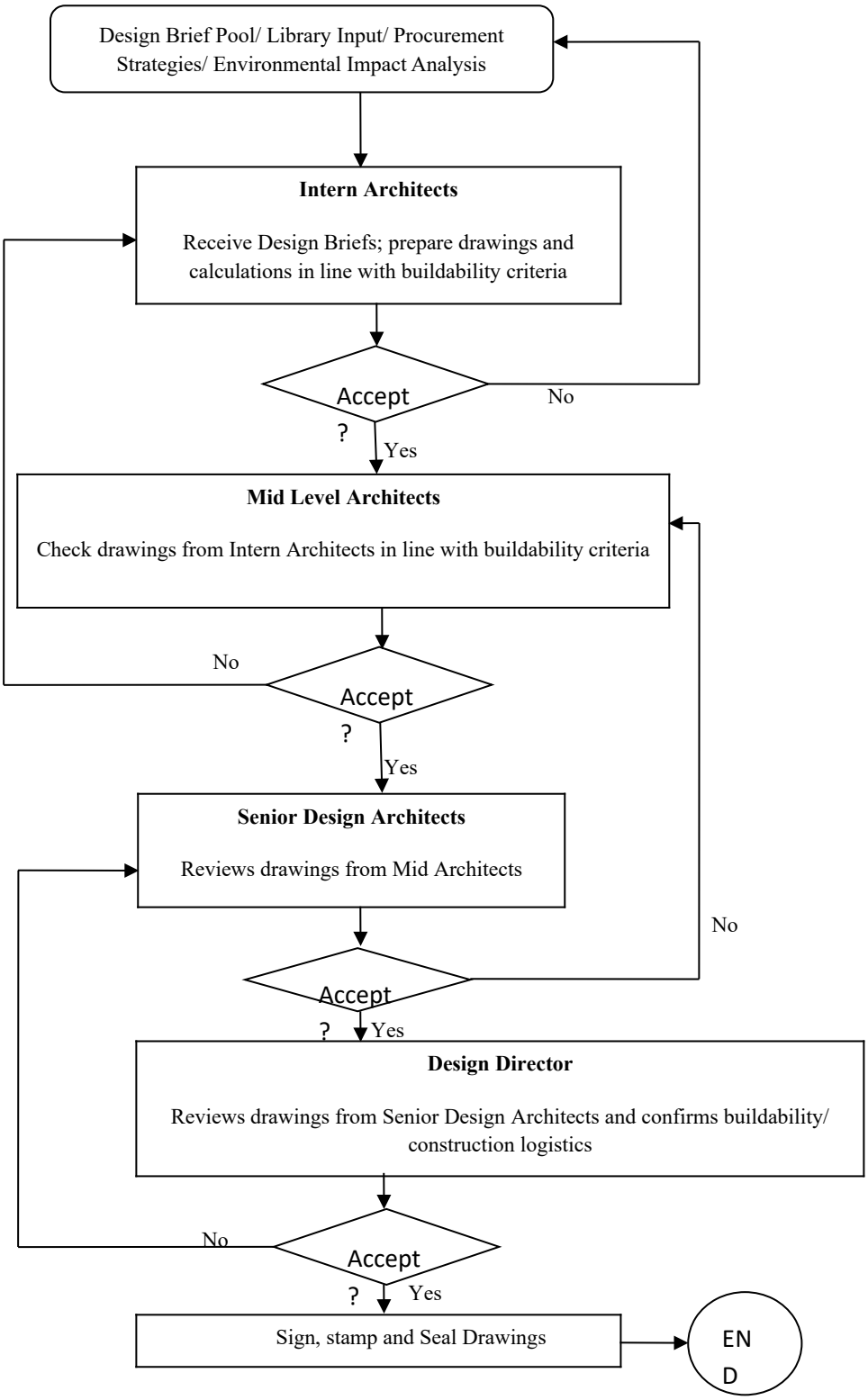

Figure 6: UML diagram for buildability and construction logistics of a Project (Researchers' fieldwork, 2023)

4.0 Conclusion

The design of functional construction processes is essential for cost effective and safe building projects. In order to manage the complexities of the construction processes of buildings, the use of IDEFO diagrams and UML activity diagrams is advocated. Construction projects entail multi-disciplinary construction processes with defined critical paths, especially at the preconstruction phase. These processes are designed in a way that there is a progressive transition from one phase to another without disruptions in activities, taking buildability attributes into each of the construction processes in addition to the use of BIM systems. Construction processes involve strategic planning, effective resource allocation, risk management, detailed programming and monitoring to achieve internationalization, sustainability and maintainability.

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