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THE DETROIT INTEGRATED TRANSPORTATION CAMPUS

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Executive Summary

This thesis proposal is focused on current construction industry issues and how they apply to the Detroit Integrated Transportation Campus (DITC). The theme of this thesis proposal is utilizing Building Information Modeling (BIM) for construction and this theme is exhibited in each analysis proposed for research.

Analysis 1

An architectural (design intent) building information model was created during the design of the DITC. An architectural (design intent) building information model is designed by the architect, and the break down and organization of this model does not typically meet the requirements to be used for BIM in construction. This problem is caused by the fact that the architect typically lacks the downstream information from contractors and suppliers required to build a model for construction. This analysis will look into the requirements of an architectural model to be used in construction for 3D coordination, 4D sequencing, unit cost estimating, constructability analysis, site utilization planning, and 3D control/planning.

Analysis 2

The design of the Detroit Integrated Transportation Campus design currently has interior walls of gypsum board on metal stud, constructed on site. Prefabricated interior wall systems are available and if substituted for the current interior wall system of the DITC would increase the speed of construction, add to the sustainability of the building, and possibly reduce cost. Analysis of this option would involve researching the construction schedule, cost, and sustainability of prefabricated interior wall systems and the process of prefabricating these systems. Constructability and 4D models will be created to help compare and convey the difference between the two systems.

Analysis 3

One-third of the DITC exterior is unitary brick on metal stud; it is a critical activity because it must wait until the exterior metal studs are installed to begin, and it has a slow rate of construction. Alternative exterior masonry wall systems are available that can give the same aesthetic look as brick on metal stud while improving the efficiency of the wall. Pre-fabricated brick panel systems can be fabricated off-site and erected on-site faster than typical brick on metal stud. Analysis would include the research of alternate systems and determine which system would be more efficient for the DITC. Constructability and 4D models will also be created to help compare and convey the difference between the two systems.

Breadth Analyses

Breadth analyses will help determine the selection of a brick façade system for analysis 3. A mechanical analysis will be performed on the thermal efficiencies of the different systems, and a structural analysis will be performed on the loads and structural connections of each system.

Analysis 1: Designing the Design Model

Problem Statement

An architectural (design intent) building model is designed by the architect and includes components such as exterior walls, roofing, windows, doors, interior walls, ceilings, flooring, finishes, millwork, fixtures, ECT. Architects typically build an architectural model for design intent purposes, and the break down and organization of an architectural model does not typically meet the needs for that model to be used for construction. This problem is caused by the fact that the architect typically lacks the downstream information from contractors and suppliers required to build a model for construction.

Research Analysis

This analysis will look into the break down and organization of an architectural (design intent) building information model for use in construction. All building projects are different and have different means and methods for designing and building them. I will therefore model the process of taking downstream construction information and applying it to the design of a building information model. I will be using the Integrated Building Process Model (IBPM) created by Victor E. Sanvido in 1990 as a basis for the process model I will create, and I will use $IDEF_0$ modeling methodology to do so.

In order to modify the IBPM to fit current BIM practices I will be referencing the work many organizations have already put forth attempting to set standards for designing a building information model. These works include the BIM Guide Series (GSA), the Integrated Practice Guide (AIA), BIM Guide and Addendum (AGC), the BIM Roadmap (US Army Corp of Engineers), the BIM Communications Specification (Autodesk), and the National BIM Standard (buildingSMART Alliance). I will also be interviewing industry BIM experts via phone and email for their input and review of my process model. I will ask questions regarding current BIM processes on projects, and adapting old industry practices to the new capabilities with BIM.

The architectural design for the DITC was done in 3D using Autodesk Revit; therefore this design will be part of the study. After developing the process model for "designing the design model", I will theoretically apply it to the DITC model as if it was to be used in the construction of the building. This will not only help me create a BIM for construction, but will allow me to review the effectiveness of my process model.

Expected Outcome

The output of this research will be a generic process model between developing the architectural model and using the BIM model for construction uses such as 3D coordination, digital fabrication, 3D control and planning, virtual mock-ups, 3D system design, unit price estimating, 4D planning, and site utilization planning. After the process model is created it will be used to identify the "for construction" requirements of the components in the architectural model created for the Detroit Integrated Transportation Campus. The current architectural model for the DITC created by Barton Malow Design

is not fit to be utilized for construction BIM uses, therefore the difference between this model and a “for construction” model will be substantial.

Analysis 2: Prefabrication and Modularization of Interior Walls

Problem Statement

One of the current trends within the architecture and construction industry is leaning project delivery. A way to lean the construction of a project is through the prefabrication of building systems. Prefabrication involves fabricating a system off site, bringing it to site in pieces, and installing those pieces on site. This process ensures quality because the systems are fabricated in shops; it also saves cost of on-site construction, and increases the rate of construction. The design of the Detroit Integrated Transportation Campus design currently has interior walls of gypsum board on metal stud, constructed on site. This interior wall system is currently on the critical path and if accelerated could decrease the overall schedule of construction. Typical gypsum board on metal stud is not a sustainable construction because interior renovation sometimes includes the demolition of these walls.

Research Analysis

Prefabricated interior wall systems are available and if substituted for the current interior wall system of the DITC would increase the speed of construction, add to the sustainability of the building, and possibly reduce cost. Analysis of this option would involve researching prefabricated interior wall systems and the process of prefabricating these systems, including the design of modular walls that have items within them, such as electrical wiring and mechanical piping. Research would be conducted through literature review of prefabricated interior wall systems and interviews with suppliers of these systems. After the information is gathered from research the cost and schedule of prefabricated interior walls will be compared to the current construction, and a recommendation will be made. Constructability and 4D models will also be created to help compare and convey the differences between the two systems.

Expected Outcome

Prefabricated Interior walls can be constructed off-site while the exterior of the DITC is being constructed, and can be installed on-site once the building is enclosed. This will decrease the schedule as the on-site construction duration of the prefabricated walls will be shorter than typical gypsum board on metal studs. The on-site construction of prefabricated interior walls will also cost less because it will require less labor than typical gypsum board on metal studs. The overall cost of each system must then be compared to confirm which system costs less. The sustainability of the building design will be improved because prefabricated interior wall systems are modular in nature. Interior building renovation is more efficient with modular walls because they can be easily deconstructed and reconstructed to suit new building spaces.

Analysis 3: Unitary Brick Alternative

Problem Statement

Enclosure of the Detroit Integrated Transportation Campus is a critical milestone in the construction of the building because interior work must wait until the building is enclosed. One-third of the DITC exterior is unitary brick on metal stud; it is a critical activity because it must wait until the exterior metal studs are installed to begin, and it has a slow rate of construction. If another system is substituted for the brick on metal stud it could possibly increase the speed of construction; decrease the cost; and increase the efficiency of the building by increasing the R-Value of the exterior.

Research Analysis

Alternative exterior masonry wall systems are available that can give the same aesthetic look as brick on metal stud while improving the efficiency of the wall. Pre-fabricated brick panel systems can be fabricated off-site and brought on-site to be erected quicker than typical brick on metal stud. Another advantage is that these systems do not need exterior metal studs to be installed. This eliminates waiting for the exterior studs, and accelerates the construction of the exterior enclosure. Prefabricated brick panel systems available are pre-cast concrete brick panels and a panelized brick veneer developed by Dr. Ali Memari and Dr. Jianhai Liang of Penn State. Analysis would include the research of these two systems, helping to determine which system would be more efficient for the DITC. After a system is selected, detailed analysis of that system would then be performed to compare it to the unitary brick on metal stud. In order to effectively compare the panelized brick to the unit masonry a comprehensive study of the constructability, cost, schedule, thermal efficiency, and structural implications of each system would be performed. Constructability, 4D models, and site utilization models will also be created to help compare and convey the difference between the systems.

Expected Outcome

Panelized brick will decrease the duration of the exterior brick façade. Starting construction without waiting for exterior metal studs and a faster construction on-site will enclose the building quicker, allowing the interior work to start earlier. Determination to use panelized masonry or unit masonry will not only depend on the schedule, but will also include the cost, thermal efficiency, and structural implications of each system. After a detailed analysis including all aspects of each system is performed, a suggestion on which system to use will be made.

Analysis 3: Solar Panel Sunscreens

Problem Statement

The Detroit Integrated Transportation Campus design currently utilizes horizontal metal sunscreens above all of its horizontal ribbon windows. The sunscreens allow light to pass through the windows for day-lighting purposes, however are designed to block direct sunlight to reduce cooling costs. The sunscreens are also designed to allow direct sunlight in during the colder moths in Detroit to reduce heating costs, made possible by the variable angle of the sun throughout the year. This is a very sustainable aspect of the DITC; however it could be made more sustainable by substituting solar panel sunscreens for the current metal sunscreens. According to a recent article in the USA TODAY, solar panel prices are tumbling while energy prices are expected to increase. Although using solar panels as sunscreens would be a higher initial cost, the long term energy savings could be substantial enough to implement this option on the DITC.

Research Analysis

In order to effectively compare the solar sunscreens to the current metal sunscreens a comprehensive study of the constructability, initial cost, long term cost, schedule, thermal efficiency, and structural implications of each system would be performed. Breadth would be demonstrated by performing the design and calculation of the electrical system tie-in, and the structural alterations to the sunscreen support. Constructability and lighting analysis models will also be created to help compare and convey the difference between the systems.

Expected Outcome

Solar sunscreens will increase the initial cost of the design, however will offer cost savings in the operation of the building. Determination to use solar sunscreens or metal sunscreens will not only depend on the cost, but will also include the schedule, electrical system implications, and structural implications of each system. After a detailed analysis including all aspects of each system is performed, a suggestion on which system to use will be made.

Weight Matrix

The weight matrix in Figure 1 below displays the level of focus that will be given to each analysis, and the division of each analysis within the four prescribed research areas.

Description	Research	Value Engineering	Constructability Review	Schedule Acceleration	Total
BIM For Construction	30 %	------	5%	------	35%
Prefab Interior Walls	-----	5%	5%	5%	15%
Unitary Brick Alternative	5%	10%	5%	10%	30%
Solar Panel Sunscreens	-----	15%	5%	----	20%
Total	35%	30%	20%	15%	100%

Figure 1.

Appendix A: Breadth Analyses

Mechanical Breadth

The efficiency of a building's mechanical system relies heavily on the thermal efficiency of the exterior enclosure. In order to justify the replacement of the unitary brick masonry on metal stud with a panelized brick system, a mechanical analysis of thermal efficiency of each system must be performed. The systems to be analyzed include the existing unitary brick on metal stud, precast panelized brick, and a panelized brick veneer system developed by Dr. Ali Memari and Dr. Jianhai Liang of Penn State. The R-Value of each system will be calculated, which will then determine the most thermally efficient system. Resizing of the heating and cooling system will then be performed for the alternate systems in order to analyze the life cycle cost of each system. Either Ecotect or IES will also be utilized to determine the efficiency of each system.

Structural Breadth

Changes in a building's façade affect the structural connections required to support the façade, and the load applied on the structure of the building. In order to justify the replacement of the unitary brick masonry on metal stud with a panelized brick system, a structural analysis of the gravity loads, wind loads, and structural connections must be performed. Also the structural integrity of each system must be analyzed. The systems to be analyzed include the existing unitary brick on metal stud, precast panelized brick, and a panelized brick veneer system developed by Dr. Ali Memari and Dr. Jianhai Liang of Penn State. The gravity and wind loads will be calculated for the alternate systems, and the structural connections and support will be redesigned. The cost of the redesign for the alternate systems and the structural integrity of each system will factor into the suggestion of the most efficient system.