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Developments of Facility Management Using Building Information Modelling

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Abstract: The construction industry has been facing a paradigm shift to increase: efficiency, infrastructure value, quality and sustainability and reduce: costs, lead times and duplications, through effective collaboration and communication, wherein a considerable amount of challenge is on construction manager for successful project completion. For facility managers, Building Information Modelling software can be a powerful new tool to enhance a building's performance and manage operations more efficiently throughout a building's life. The complete BIM contains all of the building's information, from wall systems, structural systems, HVAC equipment, plumbing fixtures, door and window schedules, and finishes, right down to the manufacturer, supplier, and square footage of every material specified on the project. Many large building owners see great benefits for developing and maintaining lifecycle data for its facilities. The overall purpose of utilizing BIM for data handover and facility management is to enable facility owners to leverage design and construction data to provide safe, healthy, effective and efficient work environments. The maintenance of this data will create greater efficiencies such as having accurate as-built information to reduce the cost & time required for renovations; increasing customer satisfaction; and optimizing the operation and maintenance of the building systems to reduce energy usage. The aim of this paper is to clarify the frequently occurring maintainability problems and to investigate the potential areas that can use BIM technology to solve the maintenance problems in early the design phase.

Keywords: Building Information Modelling, Facility Management, Building life cycle, Preventive maintenance, Space management, Auto desk FMDesktop.

I. INTRODUCTION

According to the National BIM Standards, Building Information Model is "A digital representation of physical and functional characteristics of a facility and a shared knowledge resource for information about a facility forming

A reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition". A "Building Information Model" (BIM) is a parametric, computable representation of the project design including construction details developed by the Contractor and its respective consultants and subcontractors that are integrated into the model. It functions as the main source of information and communication for all participants of project especially construction managers.

Facility Managers are continually faced with the challenge of improving and standardizing the quality of information they have at their disposal, both to meet day-to-day operational needs as well as to provide reliable data to top management for effective planning and organizational management. A BIM for facility management provides visualization, access to the precise location and relationships of building systems and equipment, and access to accurate existing condition attribute data. BIM provides several advantages over traditional 2D drawings. BIM is a data-rich, object-based, intelligent and parametric digital representation of the facility. The purpose of defining a BIM for facility lifecycle management is to specify the information needed to be passed from design and construction to operations and maintenance. A BIM for facility management can automate the creation of equipment inventory lists, populate facility management systems, and reduce redundancy in the maintenance of facility data for facility management activities. Functional digital assets enable Decisions based on Accessible, Valuable, and Informative Data Systems (DAVIDS). Timely intelligent decisions add value to an enterprise. Decision makers with timely access to valuable and informative data make better decisions. Functional digital assets empower leaders to make better informed decisions more quickly. Value is a key component from every owner's perspective. Owners plan, design, construct, operate and maintain facilities for a business purpose. Adding value to services or products validates new facilities. Facilities centric information aligns operational and maintenance goals with the business purpose of the enterprise. But enterprise / business purpose centric information completes the loop and ties facilities and accompanying infrastructure to an owner's overall business strategy. Building projects often undergo many changes during the construction phase as project teams respond to needed changes and unforeseen conditions. So, BIM models must be updated continuously throughout the construction phase to incorporate and capture changes introduced through RFI's, as-built conditions, and so on. Creating an accurate record model requires updates from all participants on the project team. Contractors must continuously update the model with constructed-related changes. Design teams must incorporate design changes and coordinate these with the contractor via RFI's and change orders. Subcontractors and fabricators must provide the fabrication models used to produce manufactured components. Upon substantial completion, the design team should integrate an as-built BIM for handoff to the facility owners and operators as part of the commissioning process.

II. LITERATURE SURVEY

There is diversity in the approach to research: some research is normative, proposing frameworks and tools to guide practice; other research is laboratory based, developing new technologies; while other studies are empirical, and seeking to articulate the realities of practice. Many studies propose BIM as a solution. Below the shape of the literatures associated with the BIM Lifecycle and Sustainability, BIM in Design and Construction, BIM Technologies.

The use of BIM earlier in the process, in the design stage, is considered by a number of authors (e.g. Chun, Li et al. 2012; Fleischmann and Menges 2012; Fouchal, Hassan et al. 2012; Mela, Tiainen et al. 2012; Raisbeck 2012; Sharma 2012; Whyte, Lobo et al. 2012). These papers overlap with the work on architecture, but tend to take a broader view of the design of the built environment considering practices across occupational boundaries and professional groups. There are also a number of studies looking at effects on project managers and project management (e.g. Cheng and Wang, 2012; Di Marco, et al. 2012).

In the more technical literatures, there is a particular focus on developing new tools for the integration of knowledge and the interoperability of systems; on naming and code-checking; semantics, modelling; data capture and connections between geographic information systems (GIS) and BIM. There are also a number of generic papers on BIM (Isikdag, Underwood et al. 2012; Tah 2012; Vries 2012; Wang, Zheng et al. 2012); and work on developing technologies in particular focused areas such as cloud computing (Redmond, Hore et al. 2012). There is work on interoperability and the technical and social challenges of using information (e.g. Clark and Bettin 2012; Fisher 2012; Forgues, Iordanova et al. 2012; Jacob and Varghese 2012; Viljoen 2012; Wu and Hsieh 2012). This develops new tools for both the integration of knowledge in software solutions; and for interoperability. Other research explores the attitudes and behaviours (Brewer and Gajendran 2012; Hatem, Kwan et al. 2012) experimentally to examine the effectiveness of different strategies for communication.

There is however research activity that is beginning to develop new tools to use BIM in order to address a range of sustainability concerns. Russell-Smith and Lepech (2012), Recent studies are also examining the use of BIM throughout the lifecycle of construction projects, addressing issues around *as*-builts (Xuesong, Eybpoosh et al. 2012) facilities management and maintenance (Arayici, Onyenobi et al. 2012; Ebinger and Madritsch 2012; Shen, Hao et al. 2012); and looking at the life-cycle of particular materials such as concrete (Borrmann, Lukas et al. 2012).

III. BIM SOFTWARE AS A FACILITY MANAGEMENT TOOL

For facility managers, Building Information Modelling software can be a powerful new tool to enhance a building's performance and manage operations more efficiently throughout a building's life. BIM software is intended to provide a facility that forms a reliable basis for decisions during its life cycle, existing from earliest conception to demolition. It is now well entrenched in the Architecture/Construction world psyche. It also provides a way to share data through the lifecycle of the built environment, useable data directly from the building plans. At a quick glance, it appears to be the perfect solution, but as with any solution, it requires planning and dedication to the end goal to make it work. The BIM model is a useful and powerful tool in the right hands, but just like any tool, with the level of flexibility offered in the BIM model, it takes time, effort and, additional work to get something that can pass from design, construction, then to facilities management and be useful to each of those stakeholders. There are a series of discontinuities in the transmission of building data that occur throughout the typical building process. Transitions from design to construction to operation result in loss of data, added cost to reconstitute the data, and overall reduction in data integrity—the impact growing at each handover, culminating with the handover to the facility operator. BIM for Facility Management brings benefits to various stakeholder groups.

A. Benefits for maintenance workers

1. Reduces time by eliminating additional trips to the same location to carry out unscheduled work orders by providing accurate field conditions and maintenance information before leaving the office.
2. Reduces cost for repairs by providing faster response times to emergency work orders.
3. Mobile access to BIM and other linked/integrated data in the field allows access to all documentation without making trips back to the office.

B. Benefits for building operators

1. Reduce the operations and maintenance (O&M) contract costs from incomplete equipment inventories. An accurate equipment inventory can reduce O&M contracting costs from 3% to 6% by identifying and tracking facility equipment.
2. Reduces time creating equipment inventories from plans, specifications and submittals.
3. An accurate equipment inventory can generate a return on investment of 3% in energy savings by identifying all facility components that affect energy usage, require maintenance, and assist in safe operations.
4. Reduces risk and uncertainty of performing work orders by identifying building components that are not easily identified (i.e. valves).
5. Maintains links to equipment histories facilitating equipment condition assessments. An accurate equipment inventory reduces the possibility of catastrophic costs for unforeseen repairs by identifying accurate equipment locations and subcomponents.
6. Optimizes building performance by comparing actual to predicted energy performance generated from BIM using energy simulation software.
7. Provides business analytics through integration of BIM, BAS, CMMS, and GIS data, allowing better review and access to building controls, schedules, readings, and inventory. Cost and performance trending can be used to troubleshoot high tenant work order areas and identify customer satisfaction or building performance issues.

C. Benefits for design and construction teams

1. Reduces costs of re-documenting "as-built" conditions and field surveys for building renovation projects. Savings could occur from reduction in time to verify field conditions, change orders due to unforeseen conditions, reduction in destructive testing and repair costs to confirm existing conditions.
2. Greater accuracy in energy model assumptions and better estimation of energy performance.
3. Design and Construction Teams can provide higher quality building systems due to better equipment selection and specifications based on feedback from building operations.
4. Better commissioning through understanding impacts of individual HVAC components on overall HVAC system.

D. Benefits for building occupants

1. Increases satisfaction from quicker resolutions to unscheduled work orders.
2. Reduces unscheduled work orders and increased communication between tenants and building maintenance workers regarding scheduled work orders.

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IV. CURRENT ISSUES WITH FACILITY MANAGEMENT

The information about a building project that is collected and created by the project team during the planning, programming, design, and construction phases provides a vast resource of incredibly valuable data that can be used by facility owners and managers to improve the effectiveness of operations throughout the lifecycle of the building. The expanding use of BIM models for design, analysis, construction planning, 4D coordination, and fabrication creates an opportunity to capture and unify the information in these models into a record model of the as-built facility. Rather than handing off printed documentation and static records during the commissioning phase, it is far more valuable to integrate and deliver a live BIM model of the project. The information in this model can support the day-to-day operations and planning needed to ensure that the facility continues to operate reliably and at peak efficiency. This flow of building and operating information is actually cyclical. Information collected by continuously measuring, monitoring, and tracking history throughout a building's lifecycle is in turn valuable for the planning and design of future renovations and improvements as well as for new construction projects. This real-world use and performance data is needed to accurately assess the performance of our designs and improve our predictive models.

As Building Information Modeling becomes widely adopted by the construction industry, it holds undeveloped possibilities for supporting Facility Management (FM). Some FM information systems on the market claim to address the needs for FM requirement. However, the question of whether the functionalities provided by the current BIM-based FM software companies are those actually required by the FM Professionals still need to be answered. The data is required by FM professionals in the operation and maintenance phases of facilities and type of maintainability problems that frequently occur, which can be solved early in design phase, have not yet been addressed. The aim of this paper is to clarify the frequently occurring maintainability problems and to investigate the potential areas that can use BIM technology to solve the maintenance problems in early the design phase. A survey was conducted to collect perspectives from the industry practitioners for the maintenance problems and their frequency. The survey results indicated that maintainability considerations should be taken into consideration during the facility design phase. The results also address the perceived areas by practitioners that need maintainability consideration in design phase.

V. SOLUTION USING AUTODESK FMDESKTOP

Autodesk FMDesktop is a full suite of purpose-built, scalable facilities management products that can help building owners and operators integrate building data derived from BIM processes and use it to manage their facility drawings, data, assets, occupants and work requests. Autodesk FMDesktop is a graphics-capable facilities management application, with both a database component and a graphics component—giving facility managers a toolset to access and work with facility data integrated with existing facility drawings. This graphic component provides non-CAD users with simple, intuitive tools for viewing and managing graphical spatial information. From a functionality viewpoint, Autodesk FMDesktop combines the features of CAFM (computer-aided facilities management) and CMMS (Computerized maintenance management system)—with a variety of space, asset and maintenance management features.

The Autodesk FMDesktop product suite includes these major components namely Facility Manager, Facility Web, Facility Request, Facility Link. Facility Manager enables organizations to track and maintain assets and spaces, manage repair or renovation projects, and implement maintenance procedures and schedules. With Facility Manager, organizations can manage all facility drawings and data in a single environment—enabling users to query, pan, zoom, print, and share facility drawings and data. Facility Web publishes the facility data and drawings managed with Facility Manager into web formats, providing read-only access to data, drawings and reports to others in an organization.
Facility Request automates the work request process by allowing facility occupants to enter their own service requests such as corrective maintenance or moves. Facility Link for organizations with AutoCAD-based facility drawings, this module is used to connect objects in those AutoCAD drawings to records in the Autodesk FMDesktop database.

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A. Importing Facility Information

Autodesk FMDesktop connects graphical elements contained in design drawings and BIM models to backend database engines including Microsoft Access, Microsoft SQL, or Oracle. The data import features of Autodesk FMDesktop means that virtually any existing digital facility data can be easily imported into the Autodesk FMDesktop database. The DWF file format can be used to import and manage drawing information outside the native CAD or BIM environment. This method is the primary means of connecting BIM-based design information to downstream facilities management and operations. DWF technology is used to connect BIM-based building information from Revit to Autodesk FMDesktop for facilities management and operations represented in figure 1.

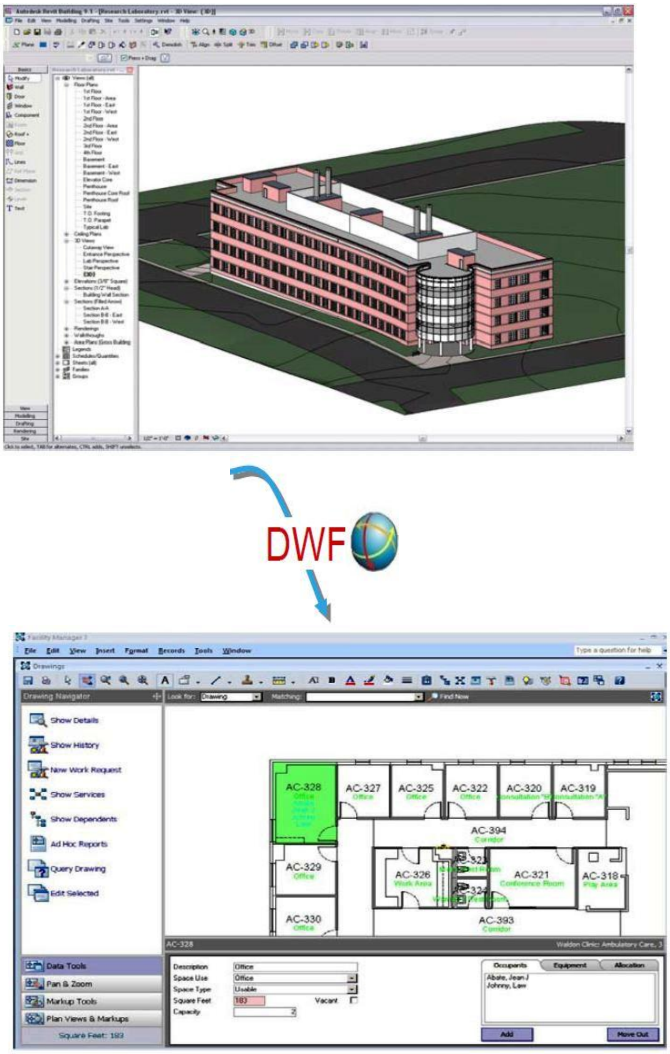

Fig. 1 DWF technology is used to connect BIM from Revit to Autodesk FMDesktop.

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B. DWF-based Space Management

DWF is a technology platform developed by Autodesk to distribute and communicate design information, without losing critical data and without the recipient needing to know or even have the native design software. In that framework, Autodesk FMDesktop reads DWFs published from BIM solutions such as Revit and automatically interprets space and room data. Traditionally architects have had difficult choices to make when their clients asked for help getting design data into their CAFM systems. But now, architects using Revit Architecture can simply publish their Revit building model to DWF and email the file to the owner having Autodesk FMDesktop. The owner imports the DWF file into Autodesk FMDesktop, which reads the room boundaries, room areas, room numbers and descriptions from the DWF, and (if applicable) compares it to the existing database to find new and removed rooms, and then updates the Autodesk FMDesktop model shown in fig. 2. In addition, DWF files can be generated from other Autodesk design products such as AutoCAD, there may be some manual data cleansing required by the facility manager. But the end result is that owners/operators using Autodesk FMDesktop can consolidate data from multiple sources. Facility managers can then use the simple tools in Autodesk FMDesktop to generate their own color-diagram room reports and their own floor plans with room numbers, areas, occupant names, and so on.

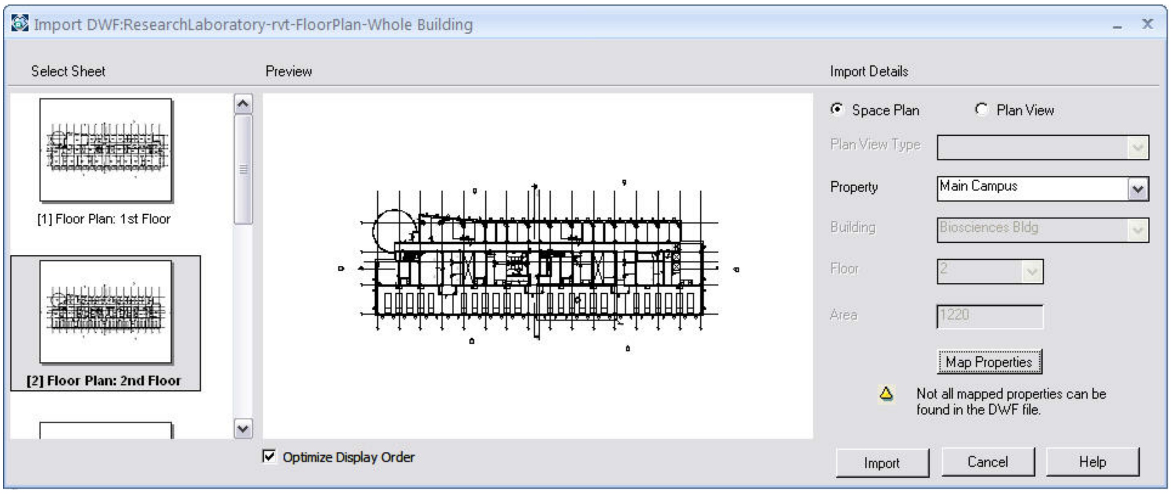

Fig. 2 Room spaces are transferred from Revit to Autodesk FMDesktop using DWF.

C. DWF-based Asset Management

DWF can also be use to migrate asset information from a Revit design model to Autodesk FMDesktop. As a building design progresses, important asset information is gradually added to a building model. During early design, generic forms of equipment or building components are depicted in the building model. For example, a 2’x2’ acoustical is ceiling panel or a horizontal air handling unit. As the design progresses and procurement occurs, these generic representations are fleshed out and updated with manufacturer-specific components. After procurement and/or installation, part-specific data such as serial numbers may be added for important equipment as shown in fig. 3.

Using DWFs to transmit the data, all of that asset information can be easily moved from the Revit design model3 into Autodesk FMDesktop. In addition, supporting documentation like warranties, installation manuals data typically included in the submittals provided by the builder to the facility owner during handover can be linked to the components in the building model and uploaded into the documents area of Autodesk FMDesktop and attached to the imported assets as shown in fig. 4.

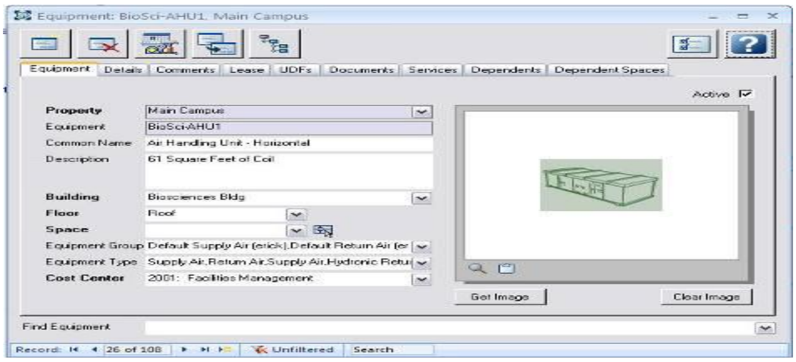

Fig. 3 Asset information contained in the Revit model is migrated into Autodesk FMDesktop.

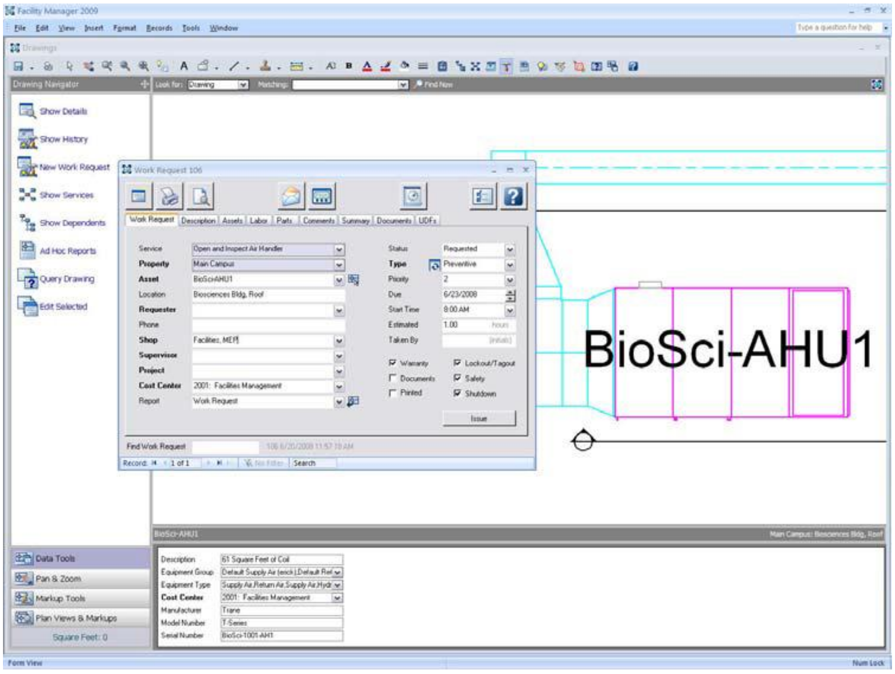

Fig. 4 Asset information showing preventative maintenance work request.

VI. CONCLUSION

Although the Autodesk Revit platform is not a facilities management software application, it provides many tools that enable users to accurately and effectively explore, track, and manage facility information using the powerful parametric capabilities of the software. Using these tools, designers and facility managers can analyse space-related data, track inventory and lifecycle data, perform cost needs analysis. The benefits of using BIM during building design have been well-publicized and transforming their drawing-based processes to model-based processes.BIM for operations and facilities management includes,

1) Programming: A spatial program to efficiently and accurately assess a design's performance and effectiveness relative to the spatial requirements.

2) Record modeling: Creating an accurate depiction of the physical conditions, environment, and assets of a facility. Using BIM models, project teams can record information relating to a facility's main architectural, structural, and MEP elements by information from BIM models used throughout the project.

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3) Preventative Maintenance Scheduling: Tracking and maintaining lifecycle information about the building structure (wall, floors, roof) as well as the equipment serving the building (mechanical, electrical, plumbing, etc.) to plan and schedule a program of maintenance activities that will improve building performance, reduce repairs, and reduce overall maintenance costs.

4) Building Systems Analysis: Measuring how a building's actual performance compares to design model predictions. Tracking performance data from the building systems and comparing these values to design model predictions enables facility managers to ensure that the building is operating to specified design and sustainable standards and identify opportunities to modify operations to improve system performance.

5) Asset Management: Linking data in a BIM record model to a database of building assets to assist in efficiently maintaining and operating the facility.

6) Space Management and Tracking: Allocating, managing, and tracking spaces and related resources within a facility. Using a BIM model for space management enables the facility team to analyze the existing use of space, evaluate proposed changes, and effectively plan for future needs.

7) Disaster Planning and Response: Using a BIM model gives emergency responders access to critical building information to improve the efficiency and effectiveness of their response and minimize the safety risks.

Facility managers using Autodesk FMDesktop can now take advantage of the reliable building information being created by Revit immediately realizing several significant benefits.DWF technology minimizes the frustration of cobbling together disparate building data from multiple design sources. But most importantly, facility managers can rest easy confident in their use of the coordinated, consistent, reliable data being delivered from the Revit design model.

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BIOGRAPHY

Ms. T. N. Brinda is into teaching from **2011** in the field **of Civil Engineering** and is presently working as an **Assistant Professor in B.S. Abdur Rahman University**, Chennai. Earlier she was awarded with B.E in Civil Engineering from **Anna University and M.Tech. in Construction Engineering Management from SRM university**, Kattankulathur in **2011**.

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E.Prasanna was born on 17th August 1991, in Tamil Nadu, India. He holds B.E in civil engineering from Anna University Chennai. Having years of experience has a Site Engineer. Presently, Pursuing Master's in Construction Management, B.S.Abdur Rahman University, Vandalur,Chennai. Recently, published papers in press with Reputed International journals.

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