Figure 1: Scan data of a building undergoing renovation

Reconciling Design Intent with Real World Existing Conditions

In building renovation, the designer's ideas must always be reconciled with the real world existing conditions. In fact, this has long been a struggle for designers and contractors alike. The technology of laser scanning is now becoming commonplace on renovation projects and is helping to rectify these struggles. Whether it is utilized by the designer or the contractor, one thing is certain; the importance of having access to accurate existing conditions information can have a big impact on the successful outcome of a project. Many are finding that laser scanning exposes where problems exist and can help the project team understand how these problems will impact their project.

The Importance of Existing Conditions Information

Typically when an architect begins work on a building renovation project the first thing needed is either a reliable set of record drawings or a good as-built survey. Either will provide the architect with information he/she needs to get started with the design process. Early on in the design process the accuracy requirements are less stringent. However, as the design progresses from schematic design to design development and on to the construction documents phase, the need for accurate existing conditions information becomes more important. The further down the design path he/she goes with inaccurate or un-validated information,

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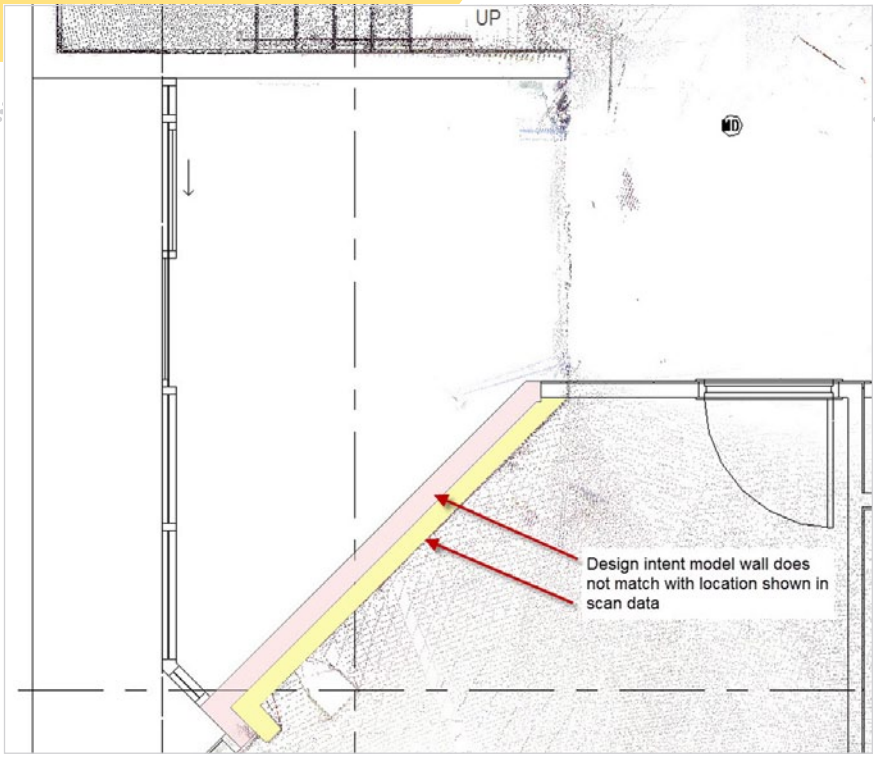

Figure 2: Scan taken after demolition revealing existing conditions framing systems once concealed, but now exposed

the bigger the impact will be and the more likely an added cost or time delay is to occur, AKA…a change order.

Architects who are provided record drawings from the owner are entitled to rely on the record drawings as being accurate. If the accuracy of the drawings is suspect, the owner may make it a requirement of the architect's contract to verify the existing conditions. Depending on the complexity of the building, the architect may, or may not, be able to verify existing conditions without expert help. It is also not uncommon that the compensation provided for this verification in the architect's contract is insufficient to perform a suitable survey. This sometimes results in the architect taking short cuts such as sending out interns with little or no experience in building documentation.

Regardless of the path taken to acquire and validate the existing conditions information, it is certain that during construction the real world conditions will be reconciled against whatever the designer used to base his/her design on.

Scanning for Design

Should the architect determine that laser scanning shall be used to perform the existing conditions verification, there are many challenges that will be faced when scanning during this phase of the project. If the building is occupied there are logistical challenges such as working around occupants and their possessions, potential security concerns and conflicts between the occupants and service provider's operations. Another common challenge is that many of the items of interest are concealed behind walls and ceilings making it difficult or impossible to accurately locate and assess important items such as structural, mechanical, electrical and plumbing (MEP) systems. All of these issues make scanning at the start of design more time consuming and costly.

Scanning for Construction

Scanning during construction can overcome many of the challenges faced vs. when scanning is implemented at the start of design. Contractors often will choose to scan the building right as demolition is coming to a conclusion. This can be the best time to scan since concealed items are typically exposed, and unwanted items have been demolished and are no longer present in the scene. Fewer scanner setups are required since interior partition walls are gone often leaving an exposed structural shell. Unwanted MEP systems have typically been removed leaving only mains. One of the biggest challenges of scanning during construction comes in the turn-around time required for the service provider's data.

Contractors may wish to have the scan data modeled which will require additional processing time. In some cases, the project schedule will not allow for the time it will take to create an existing conditions as-built model so the contractor may elect to utilize the point cloud data itself. In any event, it is clear that two paths are beginning to emerge as standard practice when contractors elect to scan during construction.

The first path is to create an existing conditions model from the scan data. This model is often comprised primarily of the remaining architectural and structural systems and sometimes the points of connection to any remaining MEP and fire protection systems. This

existing conditions model can then be used to house models which are created by the trade contractors. Thus, the mechanical sub-contractor will create his model, the electrical sub-contractor his model, and so on for the remaining trades. Common practice is to use a tool such as Autodesk's Navisworks to bring all the models together in what is referred to as a federated model. Trade coordination can then be automated where clashes between the respective models are automatically identified by the software and resolved prior to fabrication and construction. This process of constructing the building virtually prior to building it physically is saving the contractors and owners tremendous amounts of time and money.

Figure 3: Scan taken after demolition reveals existing conditions of framing systems once concealed

The second path is often taken when there isn't enough time to create an existing conditions as-built model. The contractor can simply bring the scan data into Navisworks and use it to perform a visual clash inspection with the trade models. Depending on their level of expertise in working with scan data, the trade contractors may be given the scan data to refer to when creating their model thus avoiding conflicts with the existing structure. The only thing left to coordinate then is a clash against the other trade models within the federated model. Since Navisworks currently is not able to automatically identify clashes between scan data and modeled elements, any clashes with the existing structure must be verified via visual inspection.

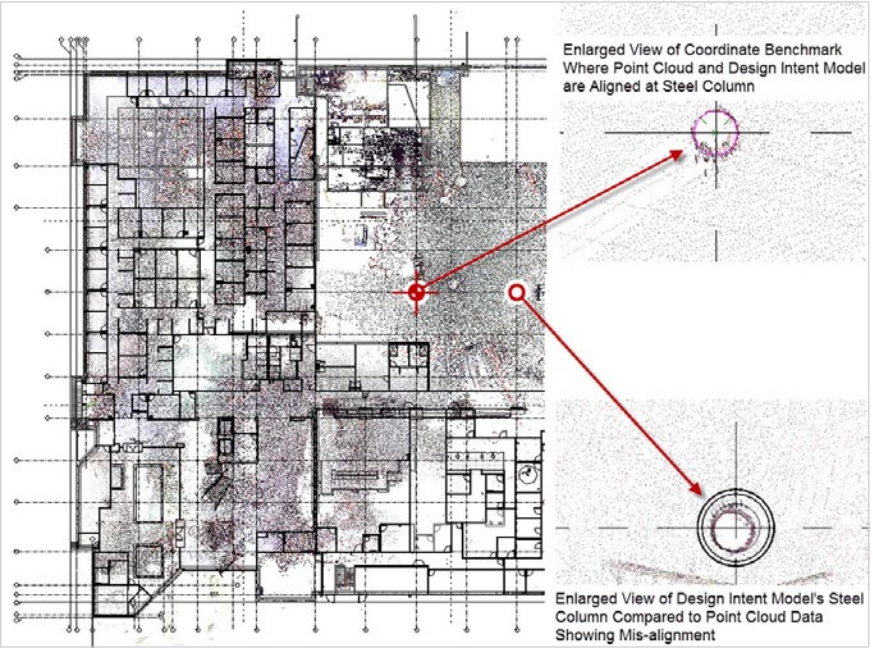

Figure 4: Comparison of scan data and design intent model reveals inaccuracies misalignment of real world steel column

Common Problems

A contractor is likely to have a building scanned when he is concerned about knowing what *really* exists, where things are *really* located and the impact these unknowns will have on the project. The following are typical examples of common problems encountered.

Alignment of Design Intent Models to Point Cloud Data

One common problem occurs when the design intent model doesn't match the actual existing conditions. This can occur when the architect relies on inaccurate record drawing information from which to base his/her design. It can

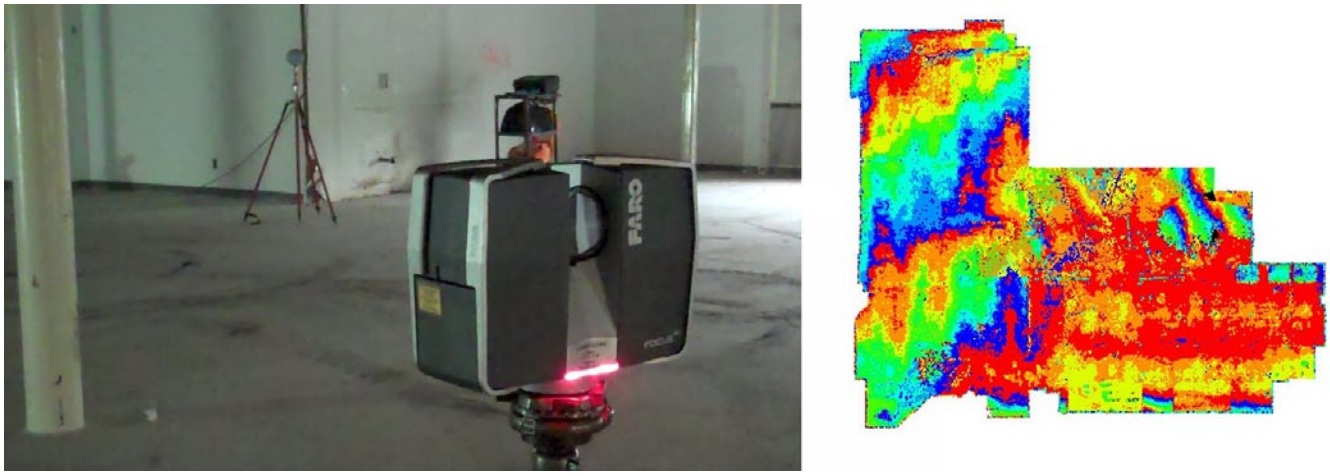

Figure 5: Laser scanner shown acquiring data and resulting image intensity floor map

also happen when a poorly executed as-built or field verification is performed. However, some problems are just unavoidable due to concealed unknown conditions that cannot be confirmed until after demolition. Nonetheless, a laser scan performed after demolition can go a long way to identifying conflicts between the design intent model and the actual existing conditions.

It is very common for a designer to begin their design intent model without regard to real world coordinates. Instead, they pick whichever random point they want as their (0,0) benchmark to begin modeling from. Without a real world coordinate, it can be difficult to align the laser scan data with the design intent model. Common features must be identified in both the scan data and the model. Exposed structural columns are often a good place to start. However, anyone who has spent any time working with point cloud data will know that columns are often not in perfect alignment on the column grid. The problem then becomes which column do you align to? Once you determine where to set your common coordinate benchmark point, who is responsible to go back and make adjustments to the design intent model?

Is the Floor Really Flat?

Floors are often thought to be flat, but are they really? Buildings *do* settle and construction tolerances are not perfect. Many problems encountered in buildings can be identified by verification of a floor's flatness. For example, failing structural members can cause a floor to become out of level. Knowing that a floor is not level can help the project team identify areas of concern for further investigation. Unleveled floors can also make installation of certain floor finishes and floor assemblies fall out of compliance with the specifications. These items are easier to rectify if found early. Laser scanning is an excellent way for contractors to determine floor flatness through the use of an image intensity map of the floor. An image intensity map uses a color spectrum to illustrate elevational differences in the surface of the floor assembly. A physical benchmark can be set in the field, such as a survey nail, and used to create a point of reference for a grid on both the image intensity map and for layout purposes in the field. Grind and fill areas can then easily be identified and mapped.

In conclusion there are many problems that can occur on a renovation project due to unknown existing conditions. Identifying these issues early can save valuable time and money for all stakeholders. While validation of the existing conditions at the start of design is preferred, there most likely will always be information that cannot be validated until after demolition has occurred. It is certain though, that laser scanning is changing the way designers and contractors are going about verifying existing conditions. As a result, we are seeing scanning becoming less of a luxury and more of a standard part of the process used on renovation projects.

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