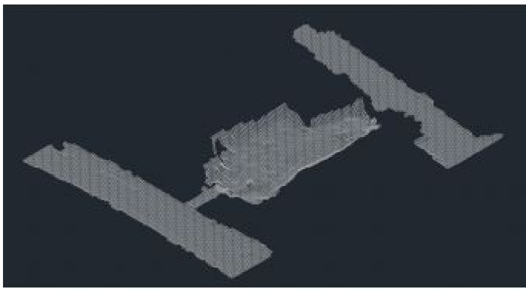
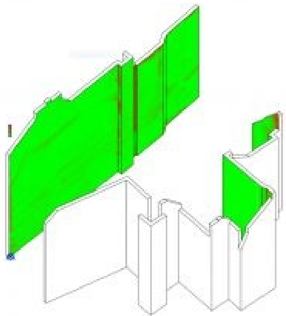
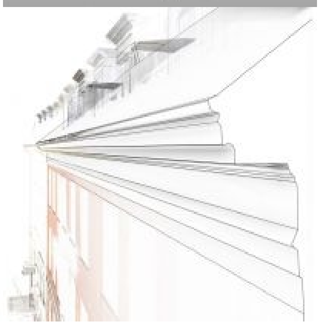
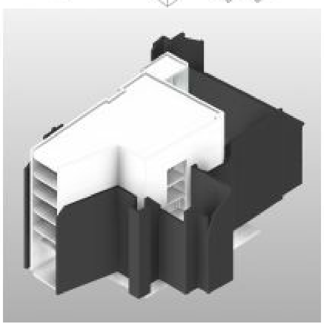
3D LASER SCANNING AND MODELLING OF EXISTING CONDITIONS

Scan-to-BIM in the Pre-design Phase









Today's high demand for energy-efficient buildings has triggered the need for gathering documentation on existing construction conditions. This information is then used to design buildings with high consideration to the site conditions, or to allow the renovation of old buildings that can no longer meet the requirements for energy performance or comfortable living. The documentation required for this type of situation is often outdated or missing. To create an optimal design, the existing conditions need to be registered and analysed using advanced technological methods such as building information modelling (BIM) or 3D laser scanning. In a recent project in Copenhagen, Denmark, BIM and 3D laser scanning were applied together as an integrated process and methodology that brought multiple benefits in the pre-design stage.

Effective planning, coordination and sharing of expert knowledge and relevant project information are essential to architects, engineers and contractors in any type of construction project and at any stage of the project life cycle. Sustainability and energy-efficiency, on the other hand, are demands that can no longer be met using traditional architectural design methodologies. Thus, BIM and 3D laser scanning together play an important role in the creation of reliable models of existing conditions for further development of projects; intelligent parametric building models that can be used to perform various types of simulations early in the design process and ensure compliance with energy demands and other regulations, and are a strong platform for communication with the rest of the project team.

Copenhagen Case

On the main shopping street in Copenhagen (Denmark) a construction site has been hidden behind plastic covers for about 10 years. At the location of the cemetery of the oldest church in Copenhagen, Saint Clements Church (built in 1192), in a building dating back to more than 400 years ago, the first Shawarma restaurant and the famous disco Absalon opened its doors. When this building was demolished in 2008 to make room for a new one, construction workers started digging into the basement of the former disco and came across hundreds of skeletons of children from the Middle Ages. This was followed by archaeologists investigating the place and due to the financial crisis, no new construction processes have been initiated since.

Now, a new commercial building is to be built at the location of the former cemetery, while the existing construction will be renovated and converted into an office building by Zeso Architects – a renowned Danish architectural company. BIM, an intelligent model-based process, and 3D laser scanning were used to register the existing conditions, design the project faster, more economically and with less environmental impact.

Pre-design Stage

As a starting point in the pre-design stage, terrain, roads, building data and imagery were automatically generated using the Model Builder feature in Autodesk InfraWorks 360 (data sources: **Terrain** – USGS 10 and 30m DEMs from the National Elevation Dataset (NED) used for the United States, SRTMGL1 30m DEM used for latitudes between -60 and +60 degrees, ASTER GDEM v2 30m DEM used for latitudes between +60 and +83 degrees; **Roads** – OpenStreetMap's Highway and Railway datasets; **Buildings** – OpenStreetMap Building data, **Imagery** – Satellite imagery from Microsoft Bing Maps). The data was then converted into .dwg format and linked into Autodesk Revit for the performance of shadow and solar radiation studies. As some of the generated data seemed outdated or was not accurate enough, the incorporation of 3D laser scanning was deemed necessary.

Thus, the existing building, the inner court yard (the former cemetery) and the surrounding streets were scanned to form a reliable basis for further development of the project. A FARO Focus 3D x330 laser scanner was used. This scanner has a range up to 330m, an accuracy of +/- 2mm and can measure up to 976,000 points/second. The scanner not only captures laser data, but also has an integrated colour camera with up to 70 million pixels and a positioning system comprising of a GPS, a compass, a height sensor and a dual axis compensator allowing immediate positioning of the scans.

As the specific applications of the point cloud data in a building project define the needed level of detail and time required to perform the actual 3D laser scanning, careful planning was necessary prior to scanning the objects of interest. With medium resolution of the images and medium quality settings (defining the intensity of averaging), well-planned scanning sequence and an overlap of at least 30-40% between the different scanning positions, both the indoor and outdoor environments were captured in approximately 10 hours providing data with very high relative accuracy. Results that no other registration method that we have used in the past achieved, including 360 degrees coloured pictures from each scanning position. Moreover, after post-processing the data, it was made available to the whole project team as a single point cloud file that could be opened and viewed in Autodesk ReCap or directly linked into Autodesk Revit. This, furthermore, eliminated the need for future visits to the site and thus generated both time and cost savings for the whole project team.

Post-processing

Post-processing of the point cloud files generated from the various scanning positions was done using Autodesk ReCap Pro. A copy of the original file was cleaned up from all unnecessary points and only the terrain points were left intact. This file was then linked in Autodesk InfraWorks 360 and accurate terrain data of the inner court yard was automatically generated from the point cloud data. This model was exported to .dwg format to create the design proposals and do the excavation planning. Furthermore, by linking the terrain and building data from Autodesk InfraWorks 360 and the point cloud from the laser scanner into Autodesk Revit a reliable basis for the modelling of the existing buildings and their surroundings was created.

Using FARO PointSense for Revit, accurate building levels were generated from the scans. This also allowed the walls surrounding the inner court yard and the existing buildings to be roughly modelled. The deviation of the modelled surfaces from the measured point cloud was then calculated and visualised with colours indicating the distance between the two. This ensured acceptable tolerances prior to the initiation of the design.

Using FARO PointSense for Revit a detailed model of the existing building's façade elements was made so that the existing façade could be analysed to allow preservation and restoration of the 'old' view of the building.

Conclusion

The generation of reliable data of the current situation for the further development of the Copenhagen case seemed a challenging and time-consuming task prior to the incorporation of 3D laser scanning. Thanks to the advance of technology, this process turned out to be much faster, more seamless and transparent to the whole project team. BIM and 3D laser scanning were applied together as an integrated process and methodology that brought multiple benefits in the pre-design stage of the project by generating more reliable and precise data achieved more quickly than with any other method used before. What is more, these technologies will continue adding value in every aspect throughout the rest of the building's life cycle and thus, they will generate time and cost savings and ensure high-quality and well-informed decisions.