BIM-Based H&S Management for Facilities. Operations & Maintenance of Logistic Plants

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Over the years, international researches about Facility Management has become increasingly important, also thanks to the advent of the BIM methodology which integrates information from all phases of the process, and closes, ideally in a circular way, the life cycle of a building. Within the abundant maintenance operations of the buildings characterizing the Facility Management phase, one of the important aspects is the H&S planning and management for operators and maintenance technicians. This research uses a dynamic BIM-based approach for Health and Safety management during O&M phase, connected to the programmed maintenance cycles, for a historical industrial plant.
The case study presented is the former Fiat plant in Rivalta (TO), currently being converted into a warehouse and logistics facility by the FCA Group. Information comes from the project documents, from the Building Maintenance Plan and from the H&S Maintenance dossier of the building installations should linked together. All of them are going to constitute the information component (LOI) relating to the BIM object. During the construction of the BIM model, the position of each object is valuable information, fundamental for the right choice of equipment and fittings necessary for the correct execution in safe, of maintenance operations. The safety of workplaces is related, for example, to access procedures to intervention area or to the correct selection of fall protection systems.
First, an analysis on information necessary for the management of a safe O&M in a BIM environment is carry out. BIM should not be only a digitizing way for work's file, it's not only a sheet containing processes and procedures identified by the safety coordinator; BIM, in this area, can be used as intelligent tool for risk assessment and, consequently, a methodology that can be used for choosing the most appropriate systems, in order to safeguard the workers H&S.

INTRODUCTION

In the context of the abundant building maintenance operations that characterize the Facility Management phase, one of the important aspects is the planning and management of the health and safety of operators and maintainers. The aim of this research is to use the dynamic and intelligent approach based on the BIM for the management of Health and Safety in the O&M phase. In the literature there are many papers and researches in which BIM is used for the management of the maintenance phase (Kasprzak & Dubler, 2012) (S. K. Lee, An, & Yu, 2012) (Yalcinkaya, Singh, Fukuda, Bernard, & Gurumoorthy, 2014) (Arayici, Y, Onyenobi, TC and Egbu, 2012) and many papers in which BIM is applied for the management of H&S in construction sites (Zhang, Teizer, Lee, Eastman, & Venugopal, 2013) (Getuli, Ventura, Capone, & Ciribini, 2016). It is very rare, however, to find research that deals with both these topics (Wetzel & Thabet, 2015), some who deal with all that is contained in the H&S Maintenance dossier, drawn up by the safety manager; in other words, on the BIM used to design the safety management of operators during the maintenance phase, which covers the entire life cycle of the building.
The idea is to use the possibilities provided by parametric modelling to create a BIM H&S Maintenance dossier in which the safety equipment is chosen according to the position of the object to be maintained. The proposed theory is applied to scheduled maintenance cycles for a historical industrial plant. The case study presented is the former Fiat plant in Rivalta (TO), currently being transformed into warehouse and logistics by the FCA Group. The information comes from the project documents, the Building Maintenance Plan and the H&S Maintenance dossier of the building installations, which must be linked together. During the construction of the BIM model, the position of each object is a precious piece of information, fundamental for the correct choice of equipment and fittings necessary for the correct execution of maintenance operations in safety. The safety of the workplace is linked, for example, to the procedures for access to the intervention area or the correct choice of fall protection systems. In this context, BIM can be used as an intelligent tool for risk assessment. In fact, it is a methodology that can be used to choose the most appropriate systems, in order to safeguard the health and safety of workers.

BIM AND FACILITY MANAGEMENT

The O&M phase, which is part of the more extensive FM domain, covers the longer time period of a building's life cycle. Even when costs are taken into account, the FM phase generates most of the costs (S. Lee & Akin, 2011) and represents approximately 85% of the total costs of the building's life-cycle costs (Eastman, Teicholz, Sacks, & Liston, 2011). Related with this in the literature we find different data, for example, for buildings used for industrial purposes, it is estimated that the cost attributed to maintenance activities varies between 15 and 70 percent of total production (Muthu, Devadasan, Ahmed, Suresh, & Baladhandayutham, 2000). Other studies show that the total life-cycle cost of a project is 5 to 7 times higher than the initial investment costs (S. K. Lee et al., 2012) and 3 times the cost of construction (BIM Task Group, 2012).
Maintenance makes an important contribution to the maintenance and improvement of plant and equipment, product quality and safety requirements and, for this reason, forms a significant part of the operating budget of companies (Al-Najjar & Alsyouf, 2003). In addition, as the complexity of technological systems increases, maintenance costs have increased three times in ten years, from $200 billion in 1979 to $6,000 billion in 1989 (Wireman, 1990). In view of these data, it is not surprising that a

significant effort is made to use the BIM methodology in the O&M phase. The BIM is in fact a digital representation of the construction process that facilitates the exchange of information between those involved in the different phases of building screws. While BIM has been used mainly for the design and construction phase, due to the speed of visualization and coordination between disciplines, there is a growing interest in using BIM in FM activities (Fraser, 2014).

INFORMATION FOR SAFETY MANAGEMENT IN THE O&M PHASES

In the Italian context, safety management, even in the O&M phase, is entrusted in the first instance to the Safety Coordinator during the design phase, who prepares the work file, a document that provides, for each type of work, the preventive and protective measures in the building or the measures necessary to carry out maintenance. The H&S Maintenance dossier of the building installations is structured in sheets, which try to summarize the necessary information, inserting the appropriate references to the documents in which the technical information of the project is contained.
This document is regulated by Article 91, paragraph 1, letter b) of Legislative Decree 81/2008, which provides its structure in three parts: Chapter 1: Summary description of the work and indication of the parties involved, Chapter 2: Identification of the risks, preventive and protective measures endowed with the work and auxiliary measures, for foreseeable subsequent interventions on the work, such as ordinary and extraordinary maintenance, as well as other subsequent interventions already planned or planned, Chapter 3: References to existing support documentation. Annex XVI contains a standard structure of the forms to be filled in.
One of the habits is to fill in a form for each type of work, typically defined as the work to be carried out on site. Going into more detail about the contents of the sheets you can see that much of the information for the proper management of safety are related to the location and safety of the workplace where you will go to work. For this reason, a single sheet describing the preventive and protective measures for the maintenance of a luminaire can be extremely dangerous because the same lamps may have been installed at different heights or in places with different interference risks.
The procedure described in the decree provides for the updating of the file by the Safety Coordinator during the execution phase, which must keep it updated with respect to the evolution of the site and the changes made in the construction phase. Often, however, the existing sheets are updated, without customizing the risk assessment based on the exact location of the object in the building, leaving the operator the burden of recovering the project tables (stored in the offices), identify the preventive and protective measures prescribed by the CSP / CSE.
Let's not forget, in this consideration, another document, complementary to the H&S Maintenance dossier of the building installations: the maintenance plan of the building. It contains details of the maintenance operations to be carried out on each individual component, in relation to the specific product present in the building, as indicated by the manufacturer. In this document, for example, we find a very important information: the frequency of maintenance. Both documents will be managed and updated throughout the use of the building by the person in charge of maintenance and, as far as safety responsibilities are concerned, by the RSPP (Head of the Prevention and Protection Service).

CASE STUDY

The FIAT production plant in Rivalta, built about 10 kilometres from the Fiat plant in Mirafiori, is one of the historic buildings of Italian automobile production since the second half of 1967. The factory started from a building intended for mechanical processing (assembly of the suspensions of almost all Fiat models). In the short period of a year, further structures were built for the assembly of the bodies, for the slabs, for the painting and for the finishing of the cars.
The buildings, for the last two processes, were built on the opposite side of the above mentioned provincial road. An aerial road conveyor, crossing the street, ensured the connection of all the assembly lines in a bilateral sense. All the other connections, both pedestrian and by wheel, were sent back to an underground tunnel.
In 1973, another large industrial structure was built, in continuity and combined with the slab line, to house the large presses: the latter were considered inadequate for the old operating site (near the civil buildings in the Mirafiori area). Since 2002, part of the plant in disuse (to be precise, the Operating Assembly Unit) has been redeveloped and organized for the production of components. A Turinauto moulding centre and Magneti Marelli suspension systems remain active at the automotive level. In February 2018 the Fiat Chrysler Automobiles group announced the reuse of the Rivalta plant, through the deposit at the local municipality of a project that provides for the development in three years of an area for a total of 340000 square meters of which 40000 dedicated to the construction of new facilities for logistics and spare parts for the group.
The conversion of buildings B, C, D and F into a logistical warehouse and the refurbishment of a new building Z and the car storage area (former track). Currently, the demolition and dismantling of the existing systems, the asbestos reclamation and the construction of new works and technological systems are underway. Pavilion D was modelled.

Figure 1: Vista aerea dell'Ex Stabilimento FIAT di Rivalta (TO) (https://it.wikipedia.org/wiki/Fiat_Rivalta)
Figure 2: Plan of the FCA industrial district of Rivalta. The conversion of buildings B, C, D and F into a logistical warehouse and the refurbishment of a new building Z and the car storage area (former track). Currently, the demolition and dismantling of the existing systems, the asbestos reclamation and the construction of new works and technological systems are underway. Pavilion D was modelled.

THE BIM FOR THE PREPARATION OF THE H&S MAINTENANCE DOSSIER OF THE BUILDING INSTALLATIONS

The H&S Maintenance dossier of the building installations is an extremely important document, which contains all the information needed to safely carry out maintenance and intervention on the building. It is generally structured in cards, dedicated to each work that is expected to be carried out on the building or on parts of it. These sheets, defined in Annex XVI of Legislative Decree 81/2008, identify the object of maintenance and the type of intervention, together with the risks that the Safety Coordinator identifies for the operators. To these first data are necessarily attached a series of information that identify the technical characteristics of the planned work and the place of work.
Usually there is a general reference to the project tables; the third part of the dossier, in fact, obligatorily contains the list of the technical documents and their placement in the archive to help the operators who will have to intervene during the phase of use and maintenance of the asset. The main information to be retrieved is the context in which the work is located, the architectural and static structure in which it will operate and the systems installed. This series of references does not facilitate the workflow and makes it much more difficult to find information, especially if you think that it is often a matter of extraordinary maintenance or emergency situations.
Contains references to the products used, links to the technical sheets and the approval reports of the Works Director. But above all with the model you can see the context and allows you to evaluate the most suitable preparations to intervene ensuring the safety of operators.

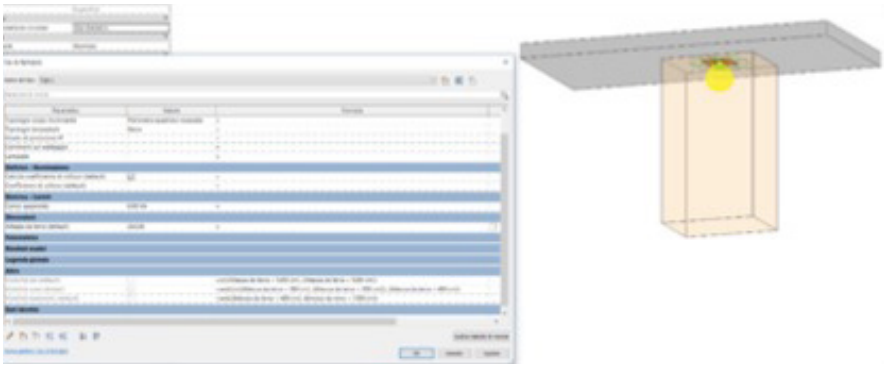
THE CHOICE OF EQUIPMENT FOR FALLING FROM A HEIGHT

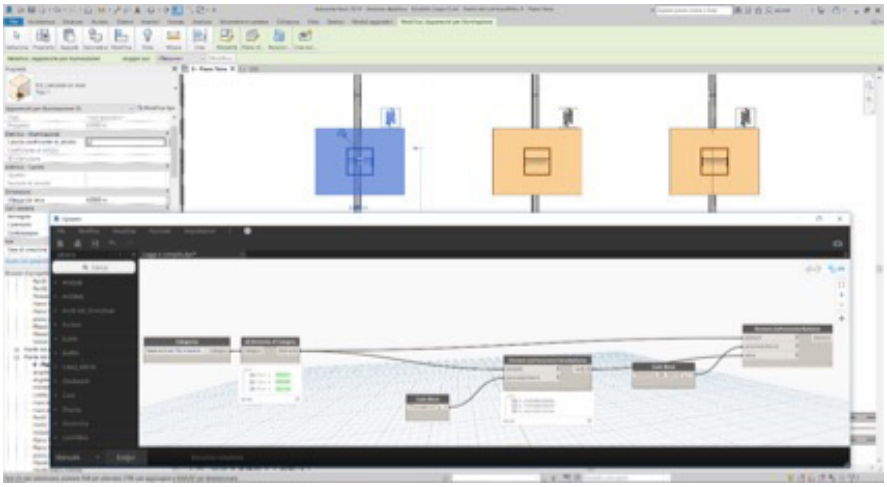
As we have seen before, one of the choices that the Coordinator must make when drafting the Work's file is the definition of preventive and protective measures regarding access and the workplace. In the case of work at a height, it is necessary to provide for the use of suitable equipment that allows maintenance operations to be carried out on plant or building objects laid at a height, safeguarding the health and safety of workers and taking into account the surrounding area.
The proposed system provides for the definition of general rules for the choice of the most suitable equipment, in relation to the height above the ground of the element being maintained. An example has been realized just on one of the lamps placed inside the hall of Rivalta. The rules inserted in the model allow to compile the parameter "height from the ground" through a Dynamo script.
This parameter identifies, according to appropriate thresholds, which will be the most appropriate preparation to be used and represents it, both next to the object in the documents to be printed, and identifies the area that must be free, necessary to safely perform the work.
The limits identified in this example are:
Together with the symbol that represents the most suitable preparation, all the useful information for the use of the same could be attached. For example, all the instructions regarding the correct use, the necessary PPE, the mandatory

Range	*Proper Equipment*
2 m < height from ground < 4 m	*Use of the ladder*
4 m < height from ground < 8 m	*Use of folding mobile scaffold*
8 m < height from ground < 12 m	*Use of lifting Platform*

Table 1: Limits range for the proper equipment choice
Figure 3: Photos of the interiors of the FCA industrial district of Rivalta (http://www.studio-aea.it/realizzazioni.html?rel_id=23)

measures to be put in place before working on the object. For example, in the case of a study, a very useful piece of information is the reference to the EQ to be deactivated. Currently, this information should be sought in the as-built tables, a work that is often replaced by attempts or tests on site.
In the three-dimensional view, or in the navigation inside the model with the augmented reality, it is possible to visualize the encumbrance of the preparations, chosen in relation to the height from the ground.
This system makes it possible to identify very quickly where there may be problems of interference between objects. It is in fact immediate with the Clash Detection systems to see if, in the presence of other objects, such as shelves or systems, the planned preparation can not be used and, consequently, other systems must be imagined to allow work at height in safety.
The BIM is an obvious example of the now common habit of not treating each workplace specifically. The worksheets are completed with general information, which does not meet the actual needs of maintenance workers, who are forced to improvise each time, increasing the risk of accidents at work.





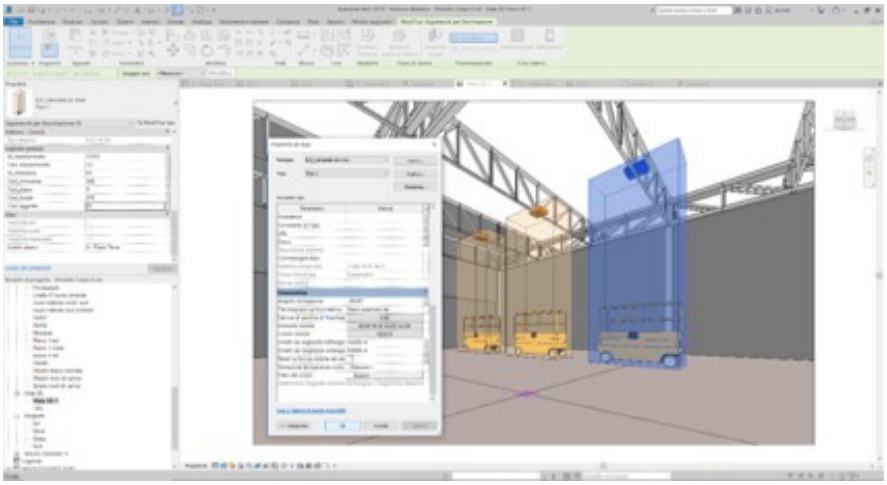


Figure 4: BIM Parametric family with different displays depending on the "height from ground" parameter (V. Villa)
Figure 5: Screenshot of the Dynamo script for the automatic compilation of the parameters in the families, and visualization of the indication of the most suitable preparation and the area necessary to carry out the maintenance. (V. Villa)
Figure 6: Screenshot of the three-dimensional view of the BIM model that displays, based on the parameter "height from the ground" of the object to be maintained, the preparation for the most suitable security. (V. Villa)

CONCLUSIONS

While the BIM for Facility Management has a good bibliography in the literature, the focus on security management during O&M operations is still little analyzed. The multiplicity of information, deriving from different documents because of the competence of different subjects, often leads to improvise the methods of intervention. Improvisation, together with the unavailability of information in the place where the operating teams are operating, leads to the occurrence of accidents at work. The proposal defined in this paper, although embryonic and to be developed in the course of future research, proposes a system for sharing information within the model, looking for rules for the definition of PCDs and IPRs needed according to the workplace. Future developments are broad and include, for example, the examination of work on roofs and work in confined environments, historically among the first causes of death during operation and maintenance.

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