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Coding Water Efficiency

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Abstract Repetitive documentation is a common theme across engineering projects. On one key project that tracked clean water leakage from pipelines across a major city, this was the case. This project involved constructing chambers around clean water mains that enabled a tracking device to be inserted into the main to identify leaks. An automation process was developed to create the designer documents faster and with a lower opportunity for human error. Similar hazards arose for each site making it simple to develop a checklist for these repetitive risks. A VBA code was written that could populate the necessary templates using data from a table. The engineer input was reduced to researching and inputting the findings in a table, saving time formatting, and typing out repetitive inputs. This enabled a larger volume of packs to be developed, additional chambers to be built, more leaks to be identified, and less water from being lost. The automation facilitates good design and risk identification, but the output will still only be as good as the input. This automation has begun with a 'home-made' approach to coding and has the potential to develop a user-friendly tool accessible across multiple projects and sectors.

Keywords: Automation, CDM, Coding, Efficiency, Water loss

1. Introduction

Many Engineering projects involve the authoring of repetitive documentation. This is the case for a key project that aims to track clean water leakage from pipelines across a major city. This project involves constructing chambers around clean water mains to enable a tracking device to be inserted into the main. The tracking device travels with the water flow along the main and identifies any leaks in the main, enabling the leak to be fixed, and a reduction in clean water loss. To enable tracking of the entire water network across the city, hundreds of these chambers are required. The tracking device gets stuck on tight bends, at junctions in the mains, or when flows are insufficient, increasing the number of chambers required. Therefore, constructing these chambers involves a lot of repetitive work: assessing the impact of repetitive hazards, evaluating flow data, and developing repetitive Pre-Construction documents. The development of an automation process has led to efficient creation of construction documentation, with assisted design.

For the designer on this project, research is required for each site to identify the likely hazards and construction constraints associated with building a chamber. This involves checking underground service maps for services that may obstruct the chamber installation, using publicly available mapping systems for finding above ground hazards like trees and streetlights, assessing flow and GIS information, and searching for potential environmental and road work issues that may inhibit construction works. A lot of similar hazards arise for each site making it simple to develop a checklist to mark yes/no against these repetitive design consideratons. Along with a checklist, a table enabling user inputs was created for more detailed design considerations, such as where a list or description of a specific hazard is required.

On this project there are two main documents that are required as part of the pre-construction pack: a Pre-Construction Information (PCI) document, and a Significant Design Risk Register (SDRR) document. A VBA code was written using the find and replace function on word, that could populate the necessary documentation templates using data from a checklist and table. The engineer no longer has to format documents, type out repetitive inputs and can focus purely on inputting the design into a table.

The time saved using this automation process enables a larger volume of packs to be developed in a set time, allowing additional chambers to be built, more leaks to be identified, and ultimately less water from being lost. The automation facilitates good design and risk identification, but the output will still only be as good as the input. Engineers are still required to assess and understand limitations which impact the design and ensure the documents are checked and approved before they can be issued to the client/contractor.

Within the legal industry, technology has been employed with the objective to "improve the efficiency, consistency, comprehensibility and predicatabliity of legal and judicial systems" (1). Similarly, this automation seeks to give rise to the same benefits sought in the legal profession.

VBA coding is not a new technology, however its application in CDM documentation within the water sector is yet to be fully utilized. Templates are often used for such documentation but as explained in this paper, templates do not provide the same benefits as automation and rely heavily on senior engineers to check and approve them, to ensure the information delivered is correct. This paper will explain a code used for the automation of PCI and SDRR documentation which was designed for use on a clean water project Mott MacDonald (MM) had Principal Designer (PD) responsibility for. It discusses the need for automation, benefits across the industry, as well as limitations of document automation.

2. Need for Automation

2.1 Repetitive nature of the project

There are some key aspects to this project which made it conducive to the development of automation. As this project has standard designs for chambers, the role of the engineer is to get the correct chamber in the correct location, to achieve sufficient coverage for leakage detection now and in the future. While each site has its own unique circumstances which need to be considered, the number of sites mean that there are often similarities, giving rise to the project having a repetitive nature.

2.2 Scope creep

Growth in scope without increase in resource is another common occurence across engineering design projects. In these instances, efficiencies in design process are ever more important. During this leakage detection project there was a requirement to increase the number of construction packs issued to the contractor within a fixed amount of time, making the need for automation paramount.

2.3 Team complexities

Engineers in a project team often come from different backgrounds and bring varied levels of experience. The automation provides an opportunity to guide the engineers through a step-by-step process, ensuring nothing is missed. This leakage detection design team is also spread across continents, yet there are factors in the design that assume a baseline knowledge of UK highway networks. The automation process gives a guide of things to be aware of, highlighting to international engineers where there may be a gap in UK-based knowledge. The streamlined design process provided by the automation is effective in providing consistency across deliverables.

2.4 Quality assurance

With an ever-changing design team, assuring high quality of deliverables can be difficult. A determination to create consistency and identify hazards early on in design was a driver behind the automation development. The automation allows for early identification of issues, ensuring the quality assurance process does not impact construction start dates. Failure to identify problems in the design early could lead to missed construction start dates and abortive work.

2.4 Desire for excellence

This automation development was driven by the strong belief that a better, more efficient way was possible.

3. Implementation of Automation

The code for the automation uses the find and replace function in word to populate the client's CDM PCI and SDRR templates. To develop the automation system, the templates were modified to address each variable. A term was created for each variable and inputted into the word templates as shown in Figure 1.

Chamber location coordinates:
Grid Reference: <<gridref>>
Easting: <<eastcoordref>>
Northing: <<northcoordref>>
Longitude: <<longref>>
Latitude: <<latref>>
What 3 Words: <<3wordsref>>

<<structuresref>> <<street>>

The depth of cover of the trunk main is <<survey4>>. The Contractor is to ensure measures appropriate to the depth of excavation are taken to manage risks associated with an excavation, refer to the Design Risk Register for more details. The plan area of excavation is expected to be no more than 3.5m x 3.5m. <<survey5>>

Figure 1. Extract from PCI Template

A table was formed with a column of the variable terms from the template against a column for the desired input, as seen in Figure 2. This was a time-consuming process, ensuring there was a variable term for every element of the original templates that requires user input. This table is later used by the code to detect the areas of the templates that need to be replaced.

CI	<<mainmatref>>
east	<<flowdirectionref>>
OQ 24165 93829	<<gridref>>
524165	<<eastcoordref>>
693829	<<northcoordref>>
-0.0043948	<<longref>>
56.12106	<<latref>>

Figure 2. Design Input for the Code (NB this location information is made up)

Next, a user-friendly table was created that gave room for each engineer to record their research on the site, as seen in Figure 3. For this project, the form was split into sections such as Admin, General Information, Flow data, Utilities, etc. There is also a yes/no tick box list, mainly focused on the commonly present features/hazards.

Main material		CI	
Downstream direction		east	*Find in flow information*
Grid reference		OQ 24165 93829	https://gridreferencefinder.com/
Easting		524165	*to 1 decimal place*
Northing		693829	*to 1 decimal place*
Longitude		-0.0043948	
Latitude		56.12106	

Figure 3. Engineer Form Example (NB this location information is made up)

The tick box list includes or removes relevant sections of the templates, prior to the details being added. For example, if the 'Is the site in the highway?' question is answered 'no', the code will first remove all sections in the template that relate to a highways site, such as the road type.

Once the form was developed, and the templates were amended such that each variable had a <<term>>

associated with it, an iterative process enabled the code input table cells to be linked with the form. This required amending the wording and requirements in the form to ensure the grammar was correct once pasted into the templates. It also meant copying some of the standard text from the original templates, into the parts of code that were linked with the yes/no table in the form. This enabled the inclusion/deletion of specific sections of text, like in the highways example above. Once the system was working, a trial period was carried out, checking that the automation was correctly filling in the templates for all sorts of sites, from highway to rural locations.

4. Benefits of Automation

As a result of automation implementation, it became easier to adapt to the changes in project scope. The key benefit is the ability to produce more construction packs that are more consistent, which can be assessed through the check and approval process. Less time is spent with checkers and approvers as a constant authoring approach is developed when the engineer puts their design through the automation process.

The biggest benefit to the client is in the delivery of more construction packs. Being able to deliver high quality construction packs that correctly identify risks and hazards, means that risks to construction gangs are reduced.

The team members who have used the automation found that the time taken in authoring a pack (PCI, SDRR and drawing) was approximately reduced by half, from a day to author a pack by hand to taking half a day using the automation. As a result, this approach will become the default in MM projects where this documentation is required.

5. When Automation is not suitable

Automation only works well for repetitive documents that have similar inputs each time. Due to the time and effort required to set up the automation system, assigning a <<term>> to each variable and developing the table so that the grammar is correct in the template population, it is unsuitable for occasional population of documents. Likewise, if the automation is to be used for a client template that is regularly changed and updated, it will require discernment to know if the time taken in regular updates and maintenance to the code is worth the time saved in authoring the documents.

The automation is helpful on this project as MM is the principal designer and therefore under CDM 2015 (2) is responsible for the development of the PCI and SDRR for every site on the project. MM was also required to issue documentation for up to 5 sites a week, making the automation a useful tool. For innovative and untested engineering solutions, the automation would not be appropriate, as the breadth and depth of unknowns would make the template development infeasible.

There is still room for human error in executing the design for a site and in the engineer's thinking, therefore the documents still need to be checked and approved manually and read over by the author prior to sending for check and approval.

Future development of this automation could investigate referencing the same online tools used by the engineer during the design process, automatically. This is an area for further research.

6. Conclusion

Engineers look for solutions to complex problems. While creating these solutions, there remains the responsibility to design in a way that eliminates foreseeable health and safety risks to anyone affected by the work and, where that is not possible, take steps to reduce, provide information about, or control those risks (2). Considering the shortage of people in the STEM labor market and the increasing challenges to us as engineers, finding efficiencies will be crucial to our success.

This application of automation in engineering, specifically for clean water networks and CDM documentation, demonstrates benefits to both the client and the engineers, especially when acting as principal designer.

With automation, time can be saved, consistent results produced, and a framework provided to ensure hazard identification is put in place.

References

1. *The Pros and Cons of Legal Automation and its Governance.* **Ugo Pagallo, Massimo Durante.** 2, s.l. : European Journal of Risk Regulation, 2016, Vol. 7, pp. 323-334.

2. **The Construction (Design and Management) Regulations 2015.**