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RESEARCH ARTICLE

Design appraisal for the construction of a water off-take channel following construction design and management regulations

Khalid Abdel Naser Abdel Rahim

Department of Civil Engineering, Faculty of Science and Technology, University of Coimbra, Rua Luís Reis dos Santos 290, 3030-790 Coimbra, Portugal

Abstract

This article presents a design appraisal for the construction of a water off-take channel following Construction Design and Management regulations (CDM). Furthermore, a case study to pump water from River Tay near the village of Luncarty requires the construction of a water off-take channel (abstraction channel). An initial section plan of water abstraction scheme has been conducted. The design will be reviewed by taking into consideration the main concerns regarding Health and Safety concerning Construction Design and Management Regulations (CDM) 2007 and its amendments in 2015. Mostly, the greatest attention will be given to the construction stage of the project where these concerns will be questioned in terms if they can be catered for in designing the water take-off channel.

Keywords: Design appraisal, Construction, Design, Management, Water Channel.

1. Introduction

The proposed project consists of a 15m long abstraction channel sustained by a solitary pier. The location of the proposed project is demonstrated in figure 1. The support pier is located beneath the pump house and mechanical equipment. Figure 2 shows the proposed design of the abstraction channel. This report will introduce a set of analyses established to investigate and revise the hazards of the water abstraction scheme at an early stage for the instance design phase to minimize the issues that might arise during the construction stage. The classification of the main Health and Safety concerns will be set up by referring to CDM 2007 regulations and its amendments in 2015 along with how these concerns will be maintained.

1.1. Background: Construction Design and Management (CDM) 2007 Regulations

The CDM regulations were initiated in 1994 to maintain a healthier and safer construction environment. It was set to correspond with the Health and Safety Work Act Barbour Environment (2009) the main aims of these regulations is to minimize accidents, injuries, illness, and deaths which might arise due to construction works. Moreover, the regulations take the absence of workers (as a result of illness) into account and give feedback on how to minimize such a concern to prevent delays in the project. This is done by providing adequate information for the designer about Health and Safety for them to identify the risks at an early stage, for instance, during the design phase. The identification of the risk at an early stage will provide a better chance of changing the design accordingly to maintain solutions to hazards that might arise during the construction stage.

In terms of management point of view, the CDM regulations 2007 and its amendments in 2015 require the identification of risks and

hazards during every stage of works. This has to be done by producing a risk assessment that has to be followed by all parties included in the works. Secondly, all the parties included in the works such as contractors, sub-contractors, coordinators, designers, and workers should be qualified to some extent to make sure they are eligible to maintain their responsibilities more safely and healthily. Thirdly, the parties should all work together to make sure that health and safety in work are maintained at all times for example, during all construction phases. Ensuring health and safety includes all individuals that might be at a risk such as, employees, visitors, public members, and people who exist on site. Generally speaking, the CDM regulations 2007 and its amendments in 2015 provides all parties with information and legal awareness of their responsibilities regarding maintaining health and safety at all times during all construction stages from the early start to the final finishes of the project.

2. Testing Part (i) Main concerns regarding Health and Safety

As a designer of the project, the main role is to identify the key health and safety issues such as hazards and risks associate with water abstraction scheme channel and manage these risks to comply with design to avoid complications and extra costs during the implementation of the project, for the example construction phase. Additionally, the designer should take the CDM regulations into account and come up with solutions to manage the risk by minimizing/avoiding it in this regard.

The general duties of a designer according to CDM regulations 2007 and its amendments in 2015 for any type of project are as follows:

*Corresponding Author: khalid.ar@outlook.com
(K.A.N. Abdel Rahim Orcid: 0000-0001-7055-1631)

- Make sure of own capability of identifying health and safety hazards.
- Provide sufficient information on risk related to the design.
- Make sure all parties including client understands their role.
- During designing the project account should be taken into consideration to health and safety risks and how to provide a design which eliminates/reduces the hazards.
- Maintain full co-operation with all parties included in the project to completely dominate and manage the hazards.

The construction process of the water abstraction scheme consists of the following:

- ❖ Construction stage 1: Foundation
- ❖ Construction Stage 2: Support pier and abstraction equipment
- ❖ Construction Stage 3: Abstraction channel
- ❖ Construction Stage 4: Pump house and mechanical equipment

In this regard the designer believes that more information should be available for each part of the structure which has to be constructed, below is an example of what is needed for each construction stage:

- Type of foundation: Raft foundation, pad foundation, or deep foundations (pile).
- Abstraction channel is going to be In-situ concrete channel, prefabricated concrete by parts, or one unit concrete channel.
- The method by which the pump house and mechanical equipment will be fitted into the abstraction channel for instance, as one unit or in separate parts.

As shown in Figure 2 the design illustrates lots of issues and hazards in terms of health and safety but the most attention will be given to the main ones. The main health and safety concerns during the construction phase with accordance with CDM Regulations 2007 according to Directgov (2011) are as follows:

- The abstraction channel rests on a steep slope as shown in figure 2. This slope might be unstable which can lead to a failure during placing the abstraction channel if the design is not taking appropriate measures. Additionally, the cranes which are situated near slope during construction might face the risk of slope collapsing. (Stability of the slope)
- Since both, the foundation and pier made from concrete the river Tay may be contaminated during constructing these parts of the structure if for instance concrete contains a hazardous substance that might cause harm to the environment. (Regulation 9 and 11)
- The labor injuries due to lack of confined working space.
- Slippage of workers from abstraction channels during working due to the existence of slippage materials. (Regulation 11)
- As presented in Figure 1, there is only one access road (farm road) to the site and due to offshore site location the accessibility of machinery, equipment, and labor is hard, thus, the buildability and maintainability are expected to be of a high cost (Regulation 11).
- The stability of the foundation, support pier and abstraction equipment during construction if the flow of water is high and the rise and fall of the river. (Regulation 9)
- Falling of labor from height and drowning in the river (Regulation 35)
- Labor working in foundation and excavations (Regulation 31)
- Cofferdams and caissons can be a serious issue for workers as they might get stuck inside it. According to CDM Regulations part 32 1(a), the cofferdams and caissons should be designed and constructed properly. Additionally, supervision should be maintained at all times by an expert person (Regulation 32).
- Lack of traffic routes for construction vehicles and concrete pumper to reach the site safely (Regulation 36).

- Fixing the pump house and mechanical equipment to the end of the abstraction channel. This requires the use of electrical/mechanical equipment which is considered as a risk to laborers since they are working near the river which indicates that the risk of electrical shocks and burns is higher due to working near water (Regulation 2).

- Storage area for materials/types of equipment and machinery parking.

- Stability of the structure as a result of carrying out construction works. (Regulation 21, No.1)

According to the above health and safety concerns, the following measures are set to minimize hazards:

- Providing labor and machinery with enough working space according to Confined Spaces regulations 1997.

- The cleanness of the site and removal of equipment from the labor's way during working should be maintained.

- Providing labor and machinery with various safety site access and exits.

- Security guards must allow only authorized individuals to enter the site.

The designer believes that to identify the concerns more precisely other information should be provided on the type of foundation to be constructed, materials, and results of odometer soil test (provides information on the strength of the soil by which measures can be set to deal with the stability of ground).

As a designer the following steps will be conducted during both design and construction stages:

i. Design phase

- During the design stage inform parties of their responsibilities especially the client.
- Investigate the health and safety hazards from the design perspective during any stage of the work.
- Set control measures for the investigated hazards.
- Check if the design needs to be changed to maintain a healthier and safer construction environment with fewer risks.
- To inform the associated parties of the responsibilities towards the Health and Safety.
- Work together with all parties and especially with CDM coordinator and sub-designers on a day to day schedule to achieve required health and safety standards.

ii. Construction phase

- Make sure everybody is considering risk assessments towards their duties during construction works.
- Maintain regular supervision of the site and check any new hazards.
- Make sure everybody is wearing the personal protective equipment during construction works.

3. Part (ii) Design of the water take-off channel

The design of the water take-off channel will face various issues during the construction stage. As a designer different points will be taken into consideration to provide a high standard of health and safety and keeping the project cost-effective and within the time set Stone (2007). The issues regarding the commencement of the channel are addressed below:

- i. Accessibility
- ii. Ground stability conditions when the services/materials are passed by the construction machinery to the site.

- iii. The rise and fall of the water level (River Tay) may lead to necessary changes in the design.
- iv. River edge slope stability might collapse when carrying out the construction work of the channel.
- v. High cofferdam borders to prevent flooding, drowning, and collapse of the channel.
- vi. Prefabricated concrete design
- vii. The placement of the pump house and mechanical equipment can cause electrical shocks and trap labors.
- viii. Maintenance

3.1. Accessibility

Since the only way to access the site as can be seen from the site location map (Figure 1) is through the farm access road which is the only and nearest road to the site. Initially, the machinery and equipment will arrive at Fairview from A9 lane and then farm access. It is assumed that there will be some residential building by which the designer will try and minimize noise to people living close to the site. Additionally, extra access roads should be provided for the flexible movement of the machinery. Though the machinery and equipment can access the site through the river Tay using a ferry, this point will not be taken into consideration due to shallow water in the river and this procedure demonstrates more hazards.

Figure 1. The location of the proposed channel and the existing access road.

Figure 2. The proposed design of the abstraction channel.

STAGE 2 LOADING DIAGRAM

Figure 3. A sketch of Cofferdam design by Barbour Environment (2009).

3.2. River edge slope stability

The slope stability can be a serious issue if not dealt with during the design stage. Firstly it causes harm to laborers and machinery working next to it during constructing the channel. Secondly, the channel can fall during the construction stage due to the upload pressure on the slope. The concerns can be dealt with by covering the slope with special slope stabilization netting to prevent such impact Johns (1992).

3.3. Rise and fall of the water level (River Tay)

The variation in the level of water in the river (rise and fall) requires an immediate solution to prevent drowning of labor during the commencement of building the channel. During the design phase, the designer will come up with a solution to this concern by taking into account high cofferdam boards. The cofferdam prevents the entrance of water to the construction environment during any unexpected rise or fall in the water level. Thus, provides dry conditions for a safer construction environment. Moreover, the statistic on the level of rising and fall of river Tay water should be considered when deciding the height of the cofferdam during the design phase. The statistical information can be obtained from the national environment council. In this regard, the designer believes that the cofferdam (Figure 3) is the most suitable option in terms of dealing with this problem and minimizes the hazards associated with health and safety.

3.4. Prefabricated concrete design

During the designing phase, the designer has various options for methods of constructing the channel to be taken into consideration. The appropriate and most suitable method with the least health and safety hazards during the construction stage will be chosen. The abstraction channel will be made of concrete. According to Newlands (2011) "Consider pre-fabrication so that sub-assemblies can be erected at ground level and then safely lifted into place" Thus, the design will consider prefabricated concrete in the design of abstraction channel. The types of prefabricated concrete channel construction are In-situ concrete channel where pumps are used to pore concrete and form the channel, prefabricated concrete by parts where these parts are joined together to form channel and one unit prefabricated concrete channel. Regarding health and safety, the In-situ concrete channel through poring seems to be the most appropriate method in the designer's point of view. This is due to more flexibility in maintaining the construction of the channel when compared to the other two methods. Although the method of pouring concrete and allowing time for concrete to dry and gain its fully strengthening properties is assumed to be the most time consuming, this method demonstrates fewer hazards. On the other hand, both the prefabricated concrete by parts channel and the one unit prefabricated concrete channel is

regarded as methods with high health and safety risks. This is due to their massive weights and sizes which require special shipment machinery to deliver them on-site and crane to place them in position for the formation of the channel. The health and safety concerns of these two methods can be simply identified as falling of material/equipment from height when using the crane.

3.5. Placement of the pump house

The placement of the pump house and mechanical equipment into the abstraction channel requires more details on how the fitting will be assembled. This can be carried out in two ways, either as one unit or in separate units. Although the one unit assemblage is less time consuming, easier to carry out, and cost-effective; the separate units system seems to be more convenient in terms of fewer hazards associate with health and safety. This is due to main reasons such as the one unit requires a crane to lift and the lower down for the placement into the channel leading to hazards such as objects falling, working on height, crushing of crane. Conversely, the separate units system is less hassle, more beneficial, and less health and safety risks. The design will consider enough spacing in the concrete where the pump house will be fitted.

3.6. Maintenance

The design will supply safe entry and exit points for maintenance of the structure in the future. Additionally, the special arrangement will be conducted for safe access to the pump house where maintenance and checks are needed for the motor pump. Moreover, the design will provide the structure with a cage attached ladders and lifebuoy in the cause of falling into the river. Finally, the structure will be surrounded by an environmentally friendly barrier to avoid the entrance of unauthorized individuals.

4. Conclusion

The CDM regulations 2007 and its amendments in 2015 are set to combine the management of the project with health and safety to maintain a better construction environment for everybody. Moreover, the CDM regulations 2007 and its amendments in 2015 and its amendments in 2015 provide the designer with solutions to minimize the risks associated with their designs from the start point of the project. The designers can improve their designs to supply healthier and safer construction works by maintaining substantial modifications to the proposed designs to fulfill the requirements of the CDM regulations 2007 and its amendments in 2015.

The main health and safety concerns with the design of the water abstraction scheme are the stability of the slope, contamination of the river Tay, injuries due to lack of confined space, fall of labors/objects from height, accessibility, buildability, maintainability, and storage area for materials. These concerns have a major influence on health and safety during the construction stage. Furthermore, the designer connected the mention concerns with the construction of the channel. The following arrangements regarding the construction of the channel have been concluded from the set of analysis carried out:

- The most appropriate health and safety option are to In-situ the concrete channel through pumping.
- The high cofferdam boarders provide dry and safer working conditions to workers.
- More access roads should be considered for construction vehicles/machinery.
- The hazards associated with the slope stability can be minimized by maintaining special slope stabilization netting.
- The usage of separate unit systems for the pump house seems to be more convenient in terms of health and safety.
- The site will include safe entry and exit points for authorized individuals.
- Providing cage attached ladders and lifebuoy for safe maintenance in the future.
- Maintaining an environmentally friendly barrier to avoid the entrance of unauthorized individuals.
- Regular checks/supervision of the site during construction works should be carried by the designer to check any new hazards. Additionally, security should prevent any unauthorized access to the site.

The designer believes that the above measures are valid to some extent and could've been backed up by more information provided on the design for more accurate assumptions. Finally, the measures were successfully set according to CDM Regulations 2007 and its

amendments in 2015 during the design phase and will maintain a healthier and safer construction environment throughout the construction stage.

Declaration of Conflict of Interests

The author declares that there is no conflict of interest.

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