DEVELOPMENT OF A DECISION SUPPORT SYSTEM FOR THE SELECTION OF GEOTEXTILES AS FILTER MEDIA IN EMBANKMENT DAMS

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Abstract

Dam safety is a major concern for facility managers. The present study focuses on development of a decision support system (DSS) for the planning and design of geosynthetics as drainage filter in embankment dams, considering, (a) case histories on past usage of geosynthetics as filters, (b) numerical modeling of flow-through-the-dam, and (c) the design methodology for filter design using geosynthetics. There are many databases available in the public domain on dams in general, dams in distress in particular and dams where geosynthetics have been used as filter media for drainage purpose. But work carried out in identifying these databases and unifying them for utilizing it for decision making process are far and few. In this research paper, the DSS developed for the selection of geotextiles as filter media in embankment dams is introduced.

KEY WORDS: Decision Support System, embankment dams, filters, geotextiles.

1. INTRODUCTION

In embankment dams, where an internal erosion threat has been identified, retrofit filters are incorporated in downstream shoulder/toe-drain of the dam. Geosynthetics as filter constitute a very attractive solution in projects where granular material is not readily available [3]. While there has been significant resistance among dam designers towards the use of new filter materials such as geotextiles, the design base and experience in their use has continued to grow [8].

In embankment dams where the base soil consists of silt, geotextiles when used as filter will be affected by clogging issue. Satisfying retention and permeability criteria would not necessarily provide for a complete filter design, as the system could fail by clogging [6]. The findings on this area of study are diverse. Thus there is a scope for study of non-clogging potential of geotextiles when used as filter in embankment dams. The findings of the experimental study assist to develop a DSS incorporating above mentioned features and design methodology for the planning and design of geotextile as filter media in embankment dams.

The DSS is specifically targeted for use of Geosynthetics as filter media in embankment dams. The Excel© is used to develop the frame work/ outline of the DSS [2]. The same concept used with the help of Excel© is programmed using Visual Basic C#. The decision support system developed allows actions for various conditions like severe wave attack or without severe wave attack case, various density conditions, variation in plasticity index values, Cu values, etc., . This condition is especially needed for selection of filters in embankment dams as there are different types of soils present at dam sites.

2. METHODOLOGY

The methodology for development of Decision Support System for the planning and design of

geosynthetics as drainage filter in embankment dam is as shown in Figure 1.

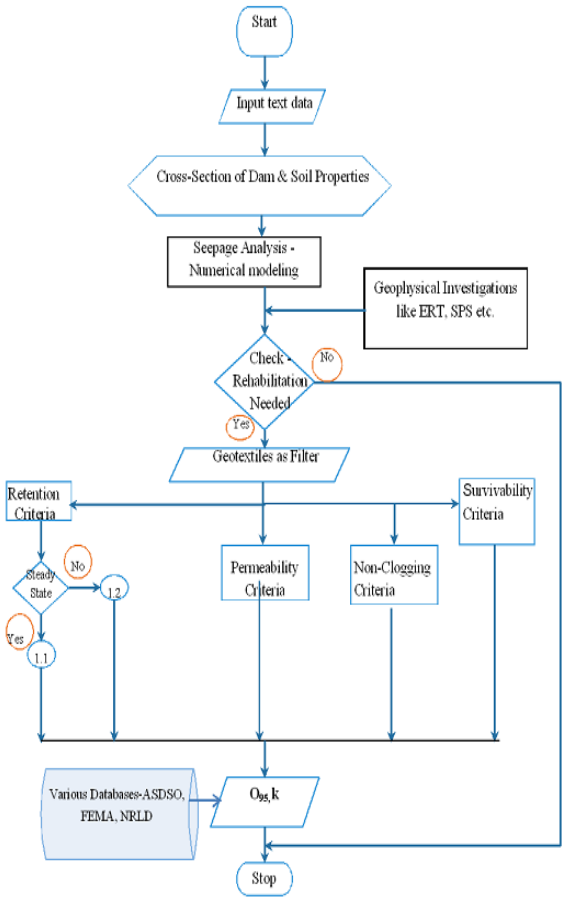

Figure 1: Flowchart for Decision Support System

In the flow chart shown in Figure 1, 1.1- Retention Criteria for dynamic flow state condition and 1.2- Retention Criteria for steady state flow condition [7]. Conclusions from experimental analysis for soil-geotextiles compatibility using gradient ratio tests conducted in the laboratory of Vidya Academy of Science and Technology, Thrissur were also incorporated as suggestions in the non-clogging criteria selection.

3. DECISION SUPPORT SYSTEM

A decision support system is developed for the planning and design of geosynthetics as drainage filter in embankment dams. Human knowledge from experience and expertise is integrated with modelling tools and available databases in the area of geosynthetics application as filter in embankment dams and an intelligent decision support system is developed to assist decision makers for the selection of geosynthetics as filter in embankment portions of dams. The DSS is developed as a virtual planning tool and can address engineering issues related with seepage problems in embankment dams. Many databases available in websites are part of DSS which share data to get informed decisions for the dam safety managers for selecting geosynthetics as filter in embankment dams. Many of them are included in the DSS developed.

The application is provided as an easy interface for the DSS, where-from the linkages to other databases or commercial software (for facilitating geotechnical analyses such as, seepage analysis, stability analysis, etc. [4]) are provided. The advantage is that while the main features of the dam under study are available in one tab, the comparisons with similar case-studies can be done in another tab. The methodolgy provides a systematic approach that includes primary steps for the design of geotextiles as filter in embankment dams. It also helps the designer to compare the obtain results with the actual case histories in a nut shell to take the final decision of geotextiles specifications as a filter in embankment dams.

4. COMPONENTS OF DSS

The DSS for embankment dams is designed with four main components in it. They are App, Database on Dams, Case History and Geosynthetics Used. The first one ‘App’ is subdivided into four - History, Seepage and Stability Analysis, Design and Final Decision. In History part, provision is given to enter details of dam such as name of dam, year of construction, type of dam, location, fatalities, estimated damages and causes.

Seepage and stability analysis of embankment dams were carried out using second tab details with the help of various software web links provided in it. The final results are entered in the space provided for it and also results from analysis can also be added. If geophysical investigation reports are available for the particular dam in distress, the pictures of results and report also can be added to the DSS.

Geosynthetics design methodology is the fourth tab which is again subdivided into Retention criteria, Permeability criteria, Anti-clogging criteria and Survivability strength requirements. Various important aspects such as internal stability condition, steady state or

dynamic flow conditions etc. are also taken into account while designing the DSS.

In Anti-clogging criteria, selection criteria for decision making process are also incorporated. ASTM code details of various performance tests are also mentioned in it. Survivability strength requirements for both high and low contact stress details are also incorporated in the design.

Once geotextiles details like A.O.S., permeability etc., are obtained for the distressed dam case, from the design methodology, provision is given to refer various case studies from past histories where geosynthetics are used as filters and drains.

Names of various databases on Dams like ICOLD World Register of Dams, INCOLD National Register of Large Dams, HKUST & IWHR (China) Database on Distressed Dams, FEMA Geotextiles in Embankment Dams, ASDSO Association of State Dam Safety Officials [1], Alaska DSP Register of Dams, AQUASTAT Middle East and Africa, and ANCOLD Guidelines on Risk Assessment are included in the DSS. Also, links are provided corresponding to each database. These dam databases and case histories are collected and collated as and when databases and new case histories are available.

In the case of Database on Dams the attributes used are Title, Text information, Figures and References. In the case History, the attributes entered in the table are Geosynthetics Function, Name and location, Embankment Height, Geosynthetics installed, Date installed, Installation Details and References. The last component is Geosynthetics used, in which Title, Text information details, Figures and References are provided.

On handling these three important components of DSS, one can refer various distressed dams; various case histories where geosynthetics are used as filters and drains, and can take informed decision for the selection of geosynthetics as filter in distressed embankment dams.

5. CASE STUDY

A case-study is regarding the distress situation in one dam from Kerala, India. Seepage analysis, stability analysis (carried out using numerical modeling) and various geophysical investigation results obtained from Irrigation Department were consolidated and need for downstream drainage filter repair is suggested. The viability of application of geosynthetics as filter in Kanjirapuzha Dam is under study. The case history search of DSS results in the rehabilitation of filter with non-woven geotextiles with apparent opening size 0.15 mm. The actual design methodology results obtained is geotextiles with large apparent opening size. The Geosynthetics filter design methodology of DSS is shown as in the Figure 2 a and 2 b. The soil- geotextiles compatibility tests were also carried out and the AOS for the non-woven geotextile which is more compatible with the base soil is obtained as 0.10 mm. From these values, it is seen that the theoretical value is higher than other cases which is to be considered seriously and decision of AOS be taken from the soil-geotextiles compatibility tests and also from the case histories from the past.

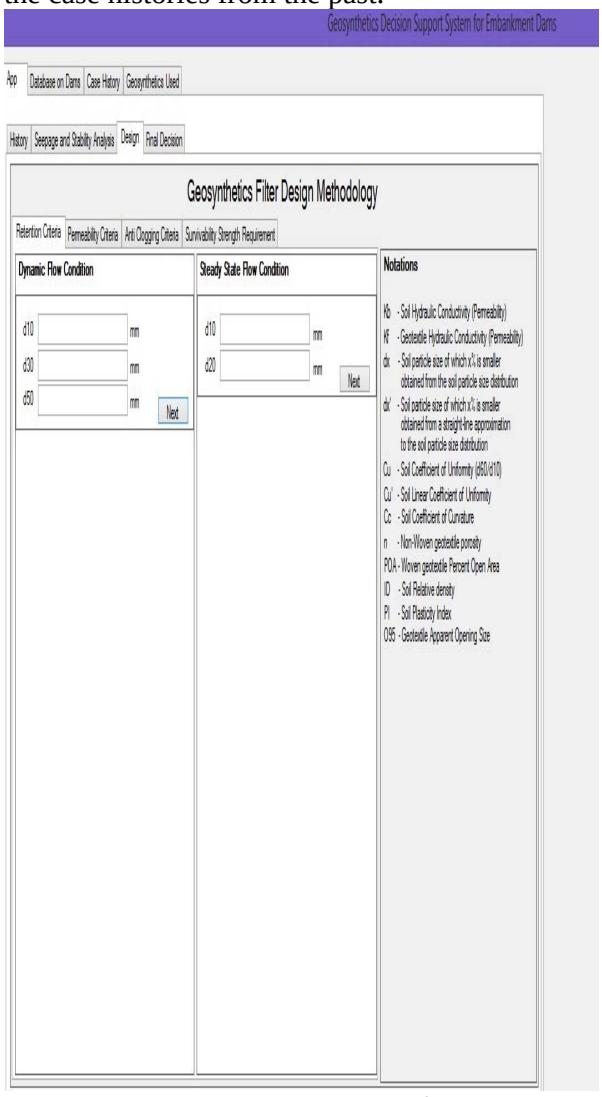

Figure 2 a: Geosynthetics filter design methodology from DSS

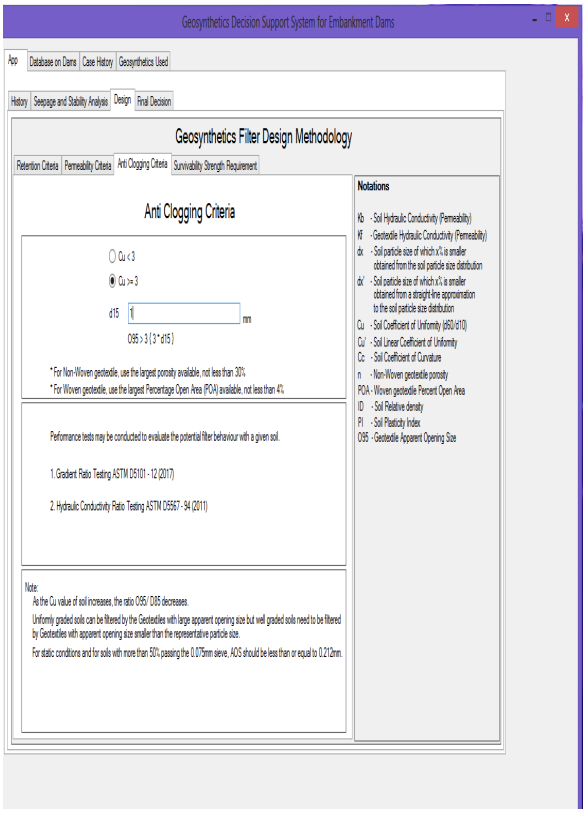

Figure 2 b: Geosynthetics filter design methodology from DSS

Thus it is concluded that the design of non- woven geotextiles as filter in embankment dam is to be done very carefully with the help of design methodology and also by taking into consideration of the past case histories of similar type. Also much importance is to be given for finding out the soil geotextiles compatibility by conducting performance analysis using tests like gradient ratio test, hydraulic conductivity tests etc. according to the nature of the base soil. In embankment dams, the base soil which constitutes silt, geosynthetics when used as filter will be affected by clogging issue. The findings of the results of gradient ratio tests and hydraulic conductivity ratio tests for various types of soils and non-woven geotextiles can be utilized during the selection process.

It is recommended that seepage and stability analysis of majority of embankment dams of Kerala state be carried out numerically and also using geophysical investigations and health status be studied. Utilization of new age material geotextiles can be done as filter media in the case of rehabilitation of drainage filter. The decision support system can be used for the selection of non-woven geotextiles as filter media in embankment dams. While selecting non-woven geotextiles, it is very important to study the case histories of similar types available in the literature which are identified and unified in the DSS evolved during this research work.

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