Database for Landslides and Engineered Slopes related to China's Water Resources Development using XML

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ABSTRACT: China is bestowed with abundant water energy resources, ranking at the first in the world in terms of hydropower. Stability of high slopes is an extremely prominent problem when developing these power stations. In this paper, the authors introduce briefly the database of slopes related to the water conservation and hydropower construction, including general information, the classification of the slope and the content of the database and so on. This slope database can provide important references for the design and construction of slopes in similar places in future. At present, XML (extensible markup language) technology is developing fast and is applied widely. XML supports data exchange between databases on the Web; it can provide network sharing of the database of slopes using XML. This paper introduces the work of establishing the web database for landslides and engineered slopes using XML technology.

1 PREFACE

China is bestowed with abundant water energy resources, most of which has not yet been developed. To-date, the installed capacity of hydropower accounts for about 24% of the state total power capacity. In the next 20 years, China will develop more large-scale hydropower projects. With the increasing number of huge dams and large-scale reservoirs, stability of high slopes will be one of the prominent concerns.

Collecting geologic and the geotechnical characteristics of engineered slopes related to hydropower development is believed to be of utmost important to understanding landslide mechanisms, and establishing reasonable analysis methods. The number of documents recording landslides is huge, but their styles, contents and levels are different. It is very difficult to utilize these record documentations if they are not undertaken in accordance with a unified methodology and format. Therefore, as early as in 1987, the work of registering landslides had started.

The landslide inventory requires the complete technical information of landslides or slopes in according with the specifically designed tables in order to build a database. In the past several years, China's water resources and hydropower workers had recorded 117 slopes with complete technical information, and published these documentations in the Web. These records will provide the reference for the design and the control of related slope projects. Fig. 1 shows the distribution of the 117 slopes and landslides related to China's hydropower development.

With the advent of the internet it is possible to create an internationally shared database for engineered slopes. Under such background, further work towards a web-based landslide and slope inventory has started.

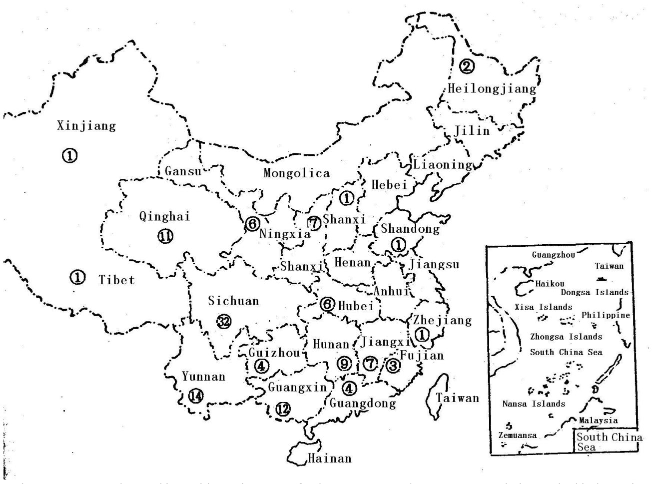

Figure1. The distribution of the 117 slopes and landslides in China (the number in each circle show the amount of slopes in the area)

In the past several years, XML (extensible markup language) technology has rapidly developed and found wide applications. Its advantages of having unique standardization, but expandable, have overcome HTML's shortcomings. It is more important that XML supports the data exchange between databases on web; we can enjoy the slope database on web by using XML technology. Now, in China, under the auspices of ISRM Commission on Case Histories in Rock Engineering, has begun some pioneering work.

2 BRIEF INTRODUCTION TO THE DATABASE

2.1 *Introduction*

The work of landslide inventory started in 1987, organized by an international initiative whose report provided the information, software and terminology of documenting landslides (Cruden and Brown, 1992).

From 1995 to 2000, under the background of "85" national key scientific and technological projects, the work of recording engineered slopes was carried on among China's water resources and hydropower community. This work recorded the basic information of engineered slope case histories using standard methods that include geology, geotechnical properties and the slope material, design parameters, construction details, and instrumentation and monitoring information, etc. (Chen, 1992).

2.2 *The database*

The content of the registered slopes covers comprehensive information that includes:

(a) Basic information: the type of slope, the geography information, the main character, the stability situation, the factor of destruction, the general description and so on.

(b) Engineering geology: rock mass structure type, lithologic character, joint, ground water, competence, earthquake, plane figure, sectional drawing, joint statistics, and rock mass quality and so on;

(c) Geotechnical mechanical character: physical and mechanical property tests of soil (within a rock mass), field tests, crustal stress tests;

(d) Design of the slope: Stability analysis, design parameters, government situation and so on;

(e) Excavation: the construction of the slope: the locations of slope excavation, the blasting technology, the situation of projectile filling, the parameters of powder holes, the security measures, the security situation of the slope, measured ground speed, acceleration and so on;

(f) Instrumentation and monitoring: Monitoring projects, instruments and arrangement, observation data and so on;

(g) The recording of slope failures and destabilization: general information, the loss situation, the landslide geometry, shape and size, failure situation, adopted engineering measures, the landslide details (sectional drawings) and so on;

(h) References: internal literature, published literature and picture and so on.

2.3 *Classifications of the database*

2.3.1 *Classifications based on the types of the slopes*

According to slope properties, engineered slopes for water conservation and hydropower can be divided into three kinds: excavation slopes, reservoir slopes and river bank slopes. The number of each kind of slope is in Table 1.

Table1. Statistics according to slope type

Classification	Excavation slope	Reservoir slope	River bank slope
Amount	42	46	29
Total		117	

2.3.2 *Classifications based on the height of the slopes*

Table 2 shows the classification and statistics of slopes registered in the documentation of the slope database based on the height of the slope.

From Table 2, one may find that in water conservation and hydropower engineering, most slopes have heights more than 100 meters, which is a prominent factor that affects the stability problems.

2.3.3 *Classifications based on the failure modes*

The failure modes of slopes include: landslide, avalanche, slide (plane, cambered surface, and wedge), topple, burst, lateral expansion, flow, and the compound mode. Statistics are shown in Table 3.

Table2. The statistical results based on the height and stability status of slopes

Slope classification	h<10m		10m<h<50m		50m<h<100m		100m<h<200m		h>200m	
	Stability	Instability	Stability	Instability	Stability	Instability	Stability	Instability	Stability	Instability
Excavation slopes	0	0	0	2	2	9	8	15	2	4
Reservoir slopes	1	0	0	0	1	0	6	2	18	18
River bank slopes	0	0	0	0	1	1	1	4	6	16

Table3. The statistical results of unstable slopes based on rock mass structures

Destruction type		Massive	Cataclinal	Ancataclinal	Orthoclinal	Disintegration	Loosening	Statistics	
								Number	Percent
Avalanche		1	1	2	1	0	1	6	8.6
Slide		8	10	2	6	2	23	51	72.9
Burst		0	2	0	1	0	0	3	4.3
Topple		0	0	4	0	0	1	4	5.7
Crack		1	0	0	1	0	0	2	2.8
Flow		0	0	0	0	0	0	0	0
Compound		0	1	2	1	0	0	4	5.7
Statistics	Total	10	14	10	10	26		70	100
	Percent	14.3	20.0	14.3	14.3	37.1			100

2.3.4 *Classifications based on the rock mass structures*

The rock mass structure of a slope can be divided into 6 types that are: massive, layered (including cataclinal, anaclinal and orthoclinal), disintegration and loosening. The statistical situation is shown in Table 4. The statistics result of each kind of rock mass structure of unstable slopes is shown in Table 3. According to the statistical results, slopes with bedding structures occupy the majority. The layered rock mass structure is further divided into three kinds of structures, namely: cataclinal, anaclinal and orthoclinal, for details, see Table 5. For failure modes of massive structure slopes, see Table 6.

The factors that trigger the failure can be divided into natural and man-made. The statistical results of 117 slopes in the water conservation and hydropower projects are shown in Table 7.

Table 4. The statistical results based on different rock mass structures

Rockmass construction	Massive	Synthetic layered	Reversal layered	Oblique layered	Disintegration	Loosening
Amount	14	26	15	17	3	42
Total	117					

Table 5. The statistical results based on the failure modes of inter-bedding slopes

Stability situtation	Number	Percent	Destruction type									Scale
			Avalanche	Slide			Topple	Crack	Burst	Compound	Flow	Volume (10^4m^3)
				Plane	Cambered surface	Wedge						
Instability	7	50	1	2	4							165~4200
Stability afterreating	2	14.3				1				1		22.64~30
Creep	5	35.7		2	1				2			7.0~1800
Total	4	100	1	4	5	1			2	1		

Table 6. The statistical results of massive slopes based on the failure modes

Stability Stitutation	Amount	Percent	Failure modes									Scale
			Avalanche	Slide			Topple	Crack	Burst	Compound	flow	Volume (10^4m^3)
				Plane	Cambered surface	Wedge						
Instability	3	30		1	1	1						5~9
Stability Afterreating	6	60	1	3		2						0.01~140
Creep	1	10				3		1				15.6
Total	3	30		1	1	1						5~9

Table 7. The statistical results based on the triggering factors of failures

Factor	Amount	Failure modes				Comment
		Stability	Percent	Distortion and destruction	Percent	
Water	62	30	48.4	32	51.6	Primarily large and middle scale or giant landslides
Storm rainfull	32	15	46.9	17	53.1	
Reservoir filling	18	10	55.6	8	44.4	
Groundwater	3	1	33.3	2	66.7	
Rain induced groundwater	6	3	50	3	50	
Erosion	3	1	33.3	2	66.7	
Human activity	44	12	27.3	32	72.7	Primarily middle and small scale wedge slide, crack and Large-scale avalanche
Excavation	41	12	29.3	29	70.7	
Mining	3	0		3	100	
Others	11	4	36.4	7	63.6	Topple, avalanche and burst, slide.
Gravity	7	3	42.9	4	57.1	
Earthquake	4	1	25	3	75	
Total	117	46	39.3	71	60.7	

3 THE APPLICATION OF XML IN THE DATABASE OF SLOPE RECORDS

3.1 *Introduction of XML*

XML is a markup language and similar to HTML in programming, a subset of SGML (the Standard Generalized Markup Language to generate the standardized document of ISO8879 published in 1986). It inherits the self-defined markup character, and changes the deficiency of HTML in function, to have a more extendable character. XML has some features:

(1) Extendable. XML is a language to create markup, to create new markup to use. Thus its use level can be extended finitely;

(2) Simple to understand. XML code is text-based, unlike other database languages. So it can be edited by usual editing software. It expresses relationships directly and is easily understood;

(3) Information can be exchanged between different platforms. As XML is simple to understand, its format can be used to mark different data type. If there is an XML decoding system between the exchanging platforms, the right information can be obtained by interpreting the marked data;

(4) International. When XML was proposed, the international implications were considered. So it is founded on Unicode.

XML's files can be viewed by IE with the aide of CSS (cascading style sheets) and the extensible stylesheet language.

Because an XML-file is only used to store data, not including other information such as format etc., it is generally used to process the data. First an '.xsd' XML Schema file is created, to define the style and element character. To determine the requirements of the XML document, the '.xsd' files describes the character. It is necessary to use the same style material file in database storage. Another '.xsl' file is defined for how the XML document is viewed in a browser. The relation of XML file, '.xsd' and '.xsl' file is expressed as Figure 2 :

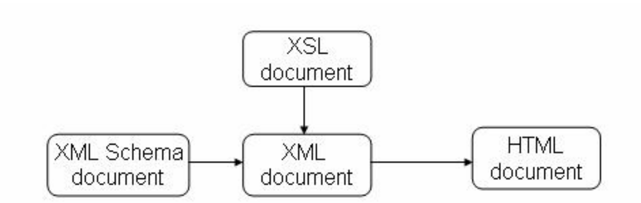

Figure2. The relationship of XML file, XML Schema and XSL document

3.2 *XML format of slope data file*

Based on the standard document of slopes, the structure file 'slopedata.xsd' was created, including all the main factors. The structure of the slopedata.xsd file is shown in Fig. 3:

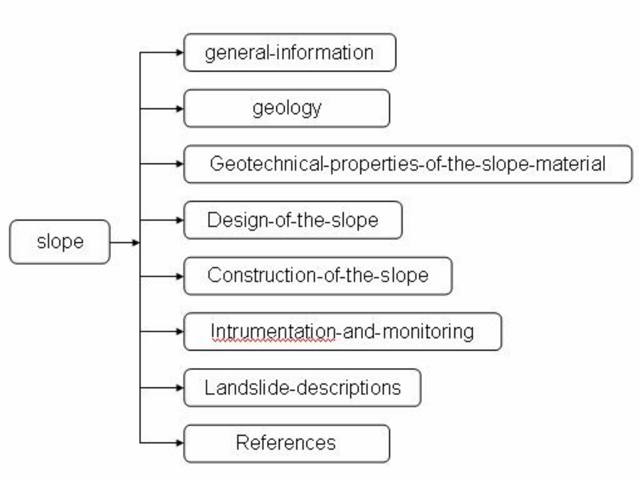

Fig 3. The structure of 'slopedata.xsd' file

In the tree-based structure, the information related to the individual structure is included for each slope case. Thus using the XML managing technology, the information can be described in detail. The combined XSL document can be displayed clearly in the user's browser.

3.3 *XML slope data file example*

Fig. 4 shows the XML data file 'manwan.xml' for the left bank slope in Manwan waterpower project using XML technology. By loading slopex.xsl, manwan.xml is displayed in IE6.0. The HTML output is shown in as Fig. 4.

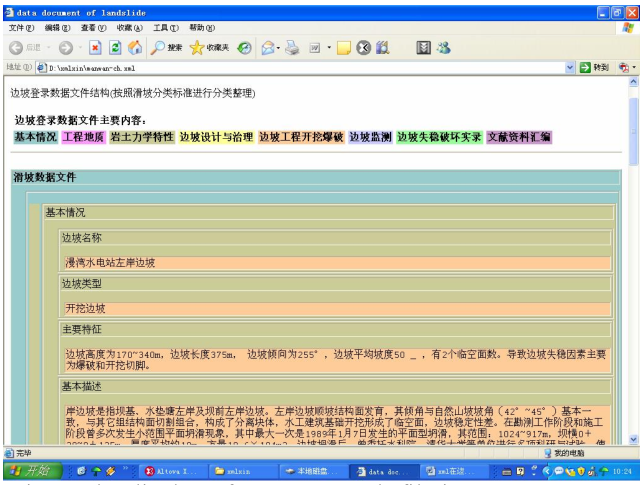

Fig 4. The display of 'manwan.xml' file in IE6.0

3.4 *Use of XML database network share*

XML has many advantages in database applications. First, it is cross-platform. An XML file is a text-based file, not restricted only to a specific OS or software platform. Second, it is simple and straight-forward. XML has the ability of a Schema self-description which can be auto-processed by computers. Third, XML describes not only the structural data, but also the sub-structural, even non-structural data.

We are now constructing a slope database based on Internet share, combining the SQL Server 2000 and XML, incorporating the network programming technology. Figure 5 is the developed structure of a SQL Sever2000 and XML combined system. According to the different system of structure and service, different access components or protocols are used. Considering the capability and programming rationale, it is often useful to couple the logic and data accesses. Thus we can using the standard components to realize it, such as OLEDB, ADO and NET API and so on.

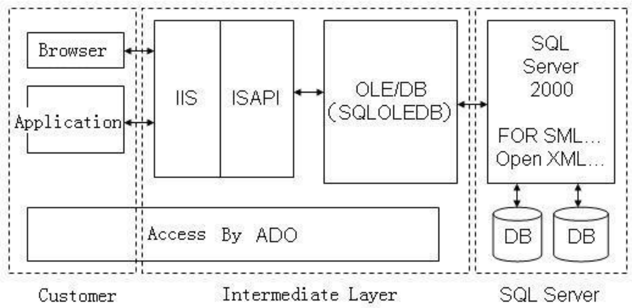

Fig 5. SQL Server's XML access system

Through the above analysis, based on the database of slopes, we can add, search or browse the slope data file through the internet. From the internet, we can share the cherished resources of our world, and every engineer of each country can obtain their relevant slope data file. This job is complicated, will require much quality work, and many people to cooperate to achieve it. But it has been started, and in the near future, we believe it can share this data on the internet.

4 CONCLUSIONS

China is developing its water power quickly, especially in Southwest areas. Stability of high slopes has been a main concern. Collecting slope data files can provide valuable references for solving high slope problems.

The advanced network and computer technology have made a database of collected slope information possible. Now the generalized XML technology can realize the data transfer across platforms. It has simple readable and extensible characters. By the related knowledge of databases, it can provide network sharing of the database of slopes using XML.

The Chinese Committee of Rock Mechanics and Engineering is working on the establishment of a slope engineering database under the help of international committees. We believe, in the near future, information on geotechnical engineering around the world can be searched and browsed on the internet by using such slope files.

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