Representing Slopes in XML

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ABSTRACT:. The paper outlines some preliminary proposals for defining an internationally agreed form of data representation for slopes and landslides. This is intended to stimulate discussion that can feed into work by Joint Technical Committee JTC2 on “Representation of Geo-Engineering Data in Electronic Form” in collaboration with JTC1 on “Landslides and Engineered Slopes”. A simple existing scheme is described for using XML (eXtensible Markup Language) for representing slope case histories. Some suggestions are made as to how XML can be used to provide representation at a variety of levels of detail in order to serve the different professional groups who use slope data. The use of GML (Geography Markup language) to define the detailed coordinate level is outlined.

1 INTRODUCTION

The paper addresses current issues of representation of slope and landslide data using XML (eXtensible Markup Language). This is part of a larger initiative to develop standard representation schemes for geo-engineering data. The three international geo-engineering societies (International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE), International Society for Rock Mechanics (ISRM) and International Association for Engineering Geology and the Environment (IAEG)) have formed a Joint Technical Committee, JTC2 (http://www.dur.ac.uk/geo-engineering/jtc2). JTC2 will oversee the development of an internationally agreed form of representation of geo-engineering data that can be used to store such data on the World Wide Web and transfer data between computer systems. This will ensure that geo-engineering data is stored in the same format anywhere on the web.

There are other benefits to having an internationally agreed data standard apart from allowing data to be made available on the World Wide Web. A standard file format can also be used for data exchange between organisations and computer systems. It could also be used for importing or exporting data to or from other software packages such as databases, GIS systems or analysis packages (Toll, 2001). It is hoped that developers of geo-engineering software will see the benefits of reading their data from a standard file format, rather than each software package having its own file format.

This paper does not intend to propose a definitive form of representation for slope data. The intention is to provide some preliminary proposals to stimulate discussion. JTC2 will be working with Joint Technical Committee for Landslides and Engineered Slopes (JTC1) (http://www.geoforum.com/jtc1/) to arrive at an internationally agreed format.

2 EXTENSIBLE MARKUP LANGUAGE

XML allows simple text files to be 'marked up' by including 'tags' within the file. These tags can be recognised by an XML compliant web browser. XML is being widely adopted by web developers for producing the next generation of web-based materials (http://www.w3.org/XML/). XML is a more generic form of mark-up language than HTML (Hyper-Text Markup Language), which has been the main language used on the World Wide Web. HTML is purely a display language that allowed tags to be introduced to define how the text would be formatted for display within a web browser. XML allows the tags to be user defined. This means that the tags can be used to give meaning to the contents of a file; for instance data can be marked up using <slope> ... </slope> tags to indicate that all data between these tags relates to slope information.

The advantage of using XML to represent data on the World Wide Web is that the data (stored in an .xml file) is separated from the formatting information. Formatting is provided by the use of a Stylesheet (.xsl) file. This means that the data can be formatted in different ways for presentation without having to make changes to the data file. This separation between data and formatting instructions is a major advantage compared to HTML where formatting commands are embedded in the data file.

It will be possible to use XML tags in order to search for files on the World Wide Web using XQuery (http://www.w3.org/TR/xquery/). This will make web-based searching much more productive and focused, rather than the keyword searching options that are currently available. However, if different data standards are adopted by different countries, the facility of being able to search easily for data anywhere in the world will be nullified.

3 EXISTING SCHEMES

An internationally agreed format can build on the IAEG suggested methods for reporting landslide data (Working Party on World Landslide Inventory, 1990; 1991; 1994). However, with the development of large datasets in GIS systems and databases it is important to develop more detailed forms of representation and ones that are suitable for electronic storage. The ongoing development of Geography Markup Language (GML) (http://www.opengis.net/gml/) and GeoScience Markup Language (GeoSciML) (http://www.opengis.net/GeoSciML/) can provide the underpinning for such a scheme. This can be supplemented by geo-engineering data. Toll (2007) outlines ongoing developments relating to geo-engineering applications.

Current work is underway to develop representation schemes for landslides, such as work in South America through the Multinational Andean Project: Geosciences for the Andean Community (http://www.pma-map.com/en/gac/). Another initiative underway in Australia is the Landslide Database Interoperability Project (Osuchowski, 2006).

4 A SIMPLE SCHEMA (SLOPESML)

Hatipoglu (2003) developed an XML schema (http://www.ins.itu.edu.tr/bulent/slopesml/) for storing case histories of slope failures. This was a very simple schema for providing generally qualitative descriptions of case histories, with a small number of tags for providing quantitative data (such as length, depth, area and volume of the failed zone). A number of examples based on this initial proposal (modified slightly to allow inclusion of images) can be found at:

http://www.dur.ac.uk/geo-engineering/geotechml/
Slopes/CaseHistoryInventory.xml

An example of an XML file and an extended version of a style sheet for displaying the case studies can be found at:

XML file: http://www.dur.ac.uk/geo-engineering/geotechml/
Slopes/Vangharad/vangharadcase.xml
XSL file: http://www.dur.ac.uk/geo-engineering/geotechml/
Slopes/SlopeSML.xsl

These simple examples are provided in order to illustrate the use of XML but the schema itself is too simple for useful representation.

5 REPRESENTING SLOPES

Slope data is used by a range of professionals: geotechnical engineers, geomorphologists, geologists and planners. They may each need to represent information in different ways (Aleotti & Chowdhury, 1999). Even if we consider only topographic information, different levels of representation are likely to be needed. Those dealing with hazard assessment will typically store data on the slope height, slope angle and aspect (as well as lithology and land use) (e.g. Wang & Sassa, 2004). Geomorphologists may want to divide a slope up into segments having different land forms. Geotechnical engineers will usually produce quantitative cross-sections showing detailed topography.

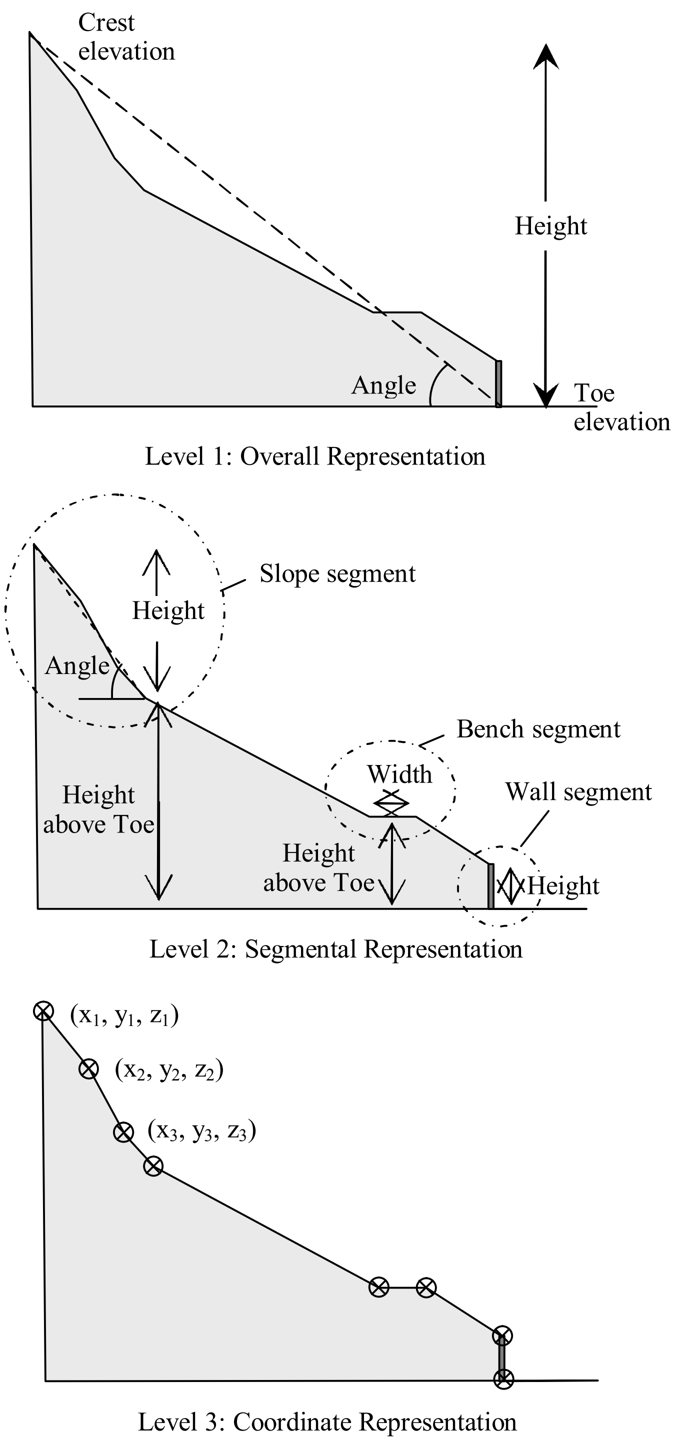

Figure 1. Three levels of representation for the same slope

It is therefore essential that a representation scheme is capable of operating at any of these different levels of representation. Figure 1 shows how three different levels of topographic detail can be used to satisfy the varying requirements.

At Level 1 the slope is defined simply by an overall slope angle and overall slope height (or Crest and Toe elevations). At Level 2 the slope is divided into segments (each referenced by height above the toe) which can be described as Slope Segments (defined by angle/height), Bench Segments (primarily defined by bench width) or Wall

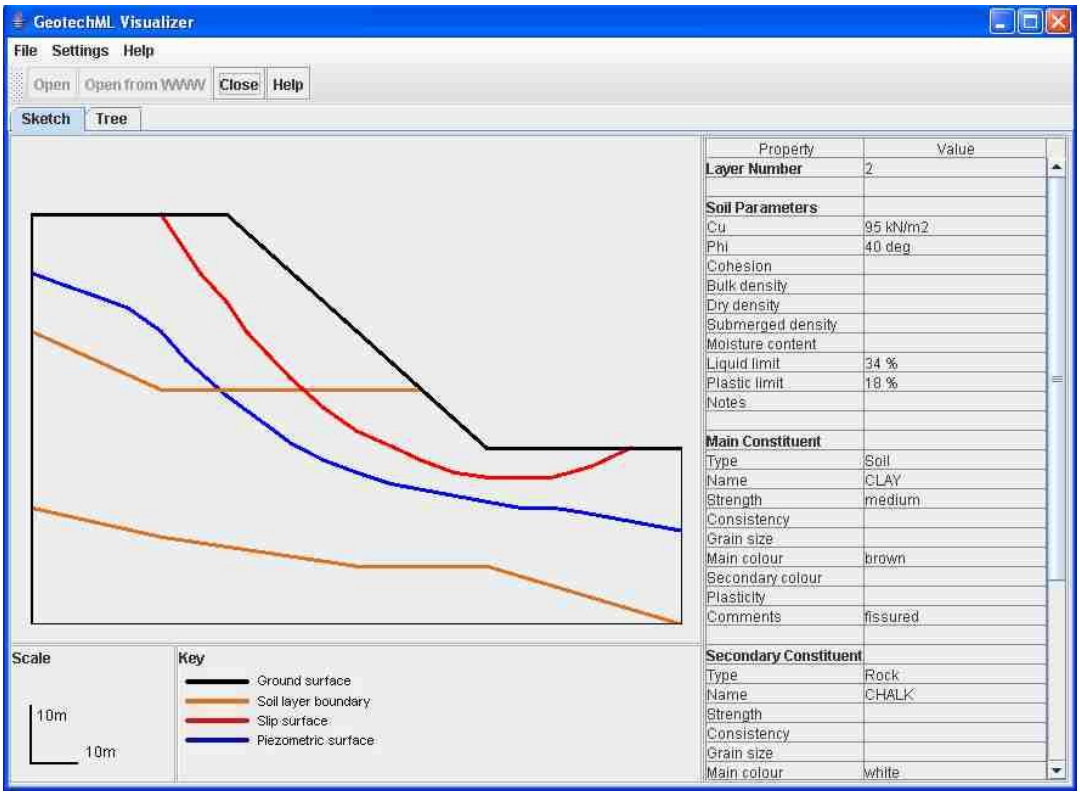

Figure 2. A Two-dimensional Graphical Representation of a Slope using GML

Segments (primarily defined by wall height). Of course, each segment can have other properties attached, such as surface cover or geomophological descriptions. At Level 3 the topography is defined by individual coordinates allowing a very detailed topographic representation (in 2D or 3D).

A listing of an XML structure for representing the data is shown in the Appendix. This is for illustrative purposes only; it is not intended to provide a complete representation or properly conform to the requirements of a GML application.

The first section of the XML file defines the locational and reporting data. The first three elements <gml:id>, <gml:description> and <gml:name> are for compatibility with GML and provide a unique identifier, a description and a name. The elements <Locality>, <NationalID> and <ReportDate> are provided for compatibility with the IAEG suggested method (Working Party on World Landslide Inventory, 1990). However, position information uses a <Location> element defined by <gml:point> as recommended by Toll (2007). Reporting data uses the "Roles" construct used by DIGGS (Data Interchange for Geotechnical and Geoenvironmental Specialists) (http://www.diggsml.org/) to define a person or organisation. In addition, a <DataSource> element is provided as landslide reports may be taken from published literature.

The Overall level (Level 1) contains data on crest and toe position, slope height/angle/shape and aspect. It also allows storage of Upslope and Downslope information, including nearby features (roads, rivers, buildings etc).

The use of GML to represent a 2D slope in terms of topography, layers of soil or rock (including geotechnical properties), ground water table and a failure surface is described by Majoribanks *et al* (in preparation). The Level 3 data is based on this proposal. The <Geometry> element uses GML constructs (e.g. <gml:point>, <gml:curve> or <gml:surface>) to represent a surface. Figure 2 shows a Java application to display the GML data graphically within a web browser.

Different levels of representation will also be needed for geological and geotechnical data. This may include (1) assigning a stratigraphic unit (2) identifying lithological, geomorphological or land-use units (3) providing a full engineering descriptions of the soil or rock (4) defining geotechnical parameters. The flexibility and hierarchical structure of XML can allow these different levels of representation to co-exist.

GML provides a full three-dimensional coordinate scheme. The developing Geoscience data standard (GeoSciML) will also support the use of three-dimensional geological models. GeoSciML is itself an application of GML and therefore will be compatible with applications developed using GML.

Representation schemes for ground investigation data such as those proposed by Toll and Shields (2003), Chandler *et al* (2006) and DIGGS can be used as the basis for defining geotechnical data. However, the form of representation for slopes will need to incorporate idealisations in the form of a ground model and simplified geotechnical parameters that would be used in stability analyses. Majoribanks *et al* suggest the need for an "interpreted" geotechnical data set that can be linked to the "raw" data obtained from a ground investigation.

6 CONCLUSIONS

It is recommended that a standard representation scheme should be developed for slopes and landslide data. The scheme will form part of a larger initiative to develop standard representation schemes for geo-engineering data. The work is being overseen by Joint Technical Committee 2 of the three international geo-engineering societies.

The scheme will need to have the flexibility to represent the data at varying levels of detail in order to suit the needs of the different professional groups who use slope data (geotechnical engineers, geomorphologists, geologists, planners etc). The use of XML (eXtensible Markup Language) can provide this flexible structure. The scheme can also make use of GML (Geography Markup Language) and GeoSciML (GeoScience Markup Language).

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Wang, H.B. and Sassa, K. (2005) *Comparative Evaluation of Landslide Susceptibility in Minamata Area, Japan*, Environmental Geology, 47, pp. 956-966.

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APPENDIX

Locational and Reporting Data

```
  <?xml version="1.0" ?>
- <CaseHistoryInventory xmlns="http://www.dur.ac.uk/geo-engineering/geotechml"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:gml="http://www.opengis.net/gml"
    xsi:schemaLocation="http://www.dur.ac.uk/geo-engineering/geotechml/Slopes/Slopes.xsd">
    <InventoryInfo>Slopes and Landslides Inventory</InventoryInfo>
    <Name>Landslide Case Histories</Name>
  - <Case CaseID="ID1">
      <gml:id />
      <gml:description />
      <gml:name />
      <Country />
      <Region />
      <City />
      <Locality />
      <NationalID />
      <Language />
      <ReportDate />
      <InventoryEntryDate />
    - <Location>
      - <gml:point srsName="urn:EPSG:geographic CRS:628364">
          <gml:pos>Latitude Longitude</gml:pos>
        </gml:point>
      </Location>
      <Roles role="Reporter" organisationOrIndividual="A.Reporter" />
    - <DataSource>
      - <Publication>
          <Authors />
          <PublicationDate />
          <PublicationType>Report/Conference/Journal/Book/Thesis</PublicationType>
          <Publisher />
          <PublisherLocation />
        </Publication>
        <URL />
      </DataSource>
```

Level 1: Overall Data

```
- <Slope>
  - <Toe>
      <Location />
      <Elevation />
    </Toe>
  - <Crest>
      <Location />
      <Elevation />
    </Crest>
  - <SlopeGeometry>
      <SlopeAngle />
      <Height />
      <ProfileShape>Concave/Linear/Convex</ProfileShape>
      <PlanShape>Concave/Linear/Convex</PlanShape>
    </SlopeGeometry>
  - <Aspect>
      <Direction>N/NE/E/SE/S/SW/W/NW</Direction>
      <Bearing />
    </Aspect>
  - <Upslope>
      <SlopeAngle />
      <Height />
      <Feature>Road/River/Building etc</Feature>
      <FeatureDistance />
    </Upslope>
  - <Downslope>
      <SlopeAngle />
      <Height />
      <Feature>Road/River/Building etc</Feature>
      <FeatureDistance />
    </Downslope>
```

Level 2: Segmental Data

```
  - <SlopeSegments>
    - <SlopeSegment>
        <SegmentID />
        <HeightAboveToe />
        <SlopeGeometry />
        <SurfaceCover />
      </SlopeSegment>
    - <BenchSegment>
        <SegmentID />
        <HeightAboveToe />
        <BenchWidth />
      </BenchSegment>
    - <WallSegment>
        <SegmentID />
        <HeightAboveToe />
        <WallType />
        <WallAngle />
      </WallSegment>
    </SlopeSegments>
```

Level 3: Coordinate Data

```
  - <SlopeCoordinates>
    - <GroundSurface>
        <Geometry />
      </GroundSurface>
    - <PhreaticSurfaces>
        <SurfaceID />
        <Geometry />
      </PhreaticSurfaces>
    - <GroundLayers>
      - <Layer>
          <LayerID />
          <Geometry />
          <GroundConditions />
        </Layer>
      </GroundLayers>
    - <RuptureSurfaces>
        <SurfaceID />
        <Geometry />
      </RuptureSurfaces>
    </SlopeCoordinates>
  </Slope>
 </Case>
</CaseHistoryInventory>
```