

# The study on the extended version of LandXML that suits Japanese road construction

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## Abstract:

In the international attempts for BIM (Building Information Modeling) application, various data models have been proposed to represent 3D road models. However, the BIM of civil engineering and construction sector is defined as the CIM (Construction Information Modeling), the unique methods used in Japanese road construction makes it difficult to directly apply them to the road designing process and softwares in Japan. This study aims to establish a data model that's more suitable for Japanese road designing process, while keeping it aligned to the international standard. Based on the internationally recognized road data model, LandXML, we'd like to propose a new extended version of LandXML, with the essential elements and features added as subsets to work with Japanese road construction.

**Keywords:** CIM, LandXML, 3D-Road-Models

## 1. INTRODUCTION

Various data models that describe 3D road structures have been proposed as part of international Construction Information Modelling (CIM) efforts. However, the BIM of civil engineering and construction sector is defined as the CIM (Construction Information Modeling), the unique methods used in Japanese road construction makes it difficult to directly apply them to the road designing process and softwares in Japan. This approach aims for efficiency and sophistication of the whole construction production system by sharing information between project associates.

In civil engineering and construction projects in Japan, submissions of 3D models have been initiated according to the standard for exchanging road alignment data (proposal) as part of CALS/EC promotion. This has been done to promote efficient projects by exchanging, sharing, and coordinating the design information, which has a high frequency of use in construction projects, among associated parties. The road alignment data are mainly used for progress control by total station (TS). In progress control via TS, the road alignment data and the cross-sectional structure are first combined to represent the road's 3D structure. A comparison is then made between the designed and the progressed structures to inspect and manage progress. This sort of control can lead to efficient overall construction management and reduced work on complete inspection, so its use was made mandatory in April 2013 for construction projects over 10,000 m<sup>3</sup>. As such, the use of 3D models in construction production cycles is steadily increasing and becoming the standard.

However, there is difficulty in that the one carrying out construction must pick each coordinate of the 2D design given by the designer. It would reduce the burden on the one carrying out construction if 3D design data could be made and used directly in the construction stage. Furthermore, if 3D models were made for the whole construction production cycle, instead of particular uses such as construction management data for progress control by TS, and used for construction, maintenance, and management, it would lead to significant improvements in sophistication and efficiency for the project as a whole. It is desirable that this comprehensive 3D model to be made in the designing stage be of a form which can easily be implemented in the existing software (3D CAD software). LandXML is an international standard 3D model compatible with numerous types of CAD and road design software. LandXML is of the XML data format developed in the U.S. in January 2000 as a data exchange standard for civil engineering and measurements. However, it is difficult to simply apply it to our road design software as the road design standards are different between the U.S. and Japan. As an example of the standard model made compatible to other design standard models, a model known as building SMART

MVD for LandXML 1.2 has been proposed in Finland to expand LandXML uniquely to its design standards.

The authors created a 3D model suitable for the construction of the production cycle from LandXML, with reference to the existing road data model. However, the 3D model according to LandXML, there are two problems. The first problem is the schema of the limit of LandXML. 3D model that conforms to LandXML has added the necessary items in the Japanese construction production cycle, using the Feature element. A feature element is an element used for adding an element that is not defined in LandXML, which allows arbitrary documentation. However, since the Feature element is a general-purpose elements, it cannot be confirmed in the schema. The second problem is occurs of the elements of the LandXML. Since LandXML is a general-purpose data format, occurs of each element is not suitable to Japan of road design.

The purpose of this study is to create a 3D design data that is suitable for the Japanese construction production cycle. First of all, a 3D model that the authors have created (hereafter, "Existing study model") to organize. Then, to create a 3D design data that extend the LandXML1.2. And, considering the concern in the case of applying a model that construction production cycle has been created.

## 2. EXISTING STUDY MODEL

Existing study model is, in compliance with the LandXML1.2, is a 3D design data you add a matching element to Japan of road design. Existing study model in order to define the road shape in the smallest element, is a model used and Alignment, the cross section perpendicular to the Alignment. Cross section defines the cross sectional component, such as a roadway or crown and slope in two ways of element definition pattern and cross section defined pattern. Element definition pattern defines the cross section width, gradient, the elevation difference. Cross section defined pattern is defined by the offset of the configuration point cross section. Definition of cross section is, design changes by defining a 3D model using a parametric road design data is facilitated, since the portion of modifications and changes are reflected in the whole.

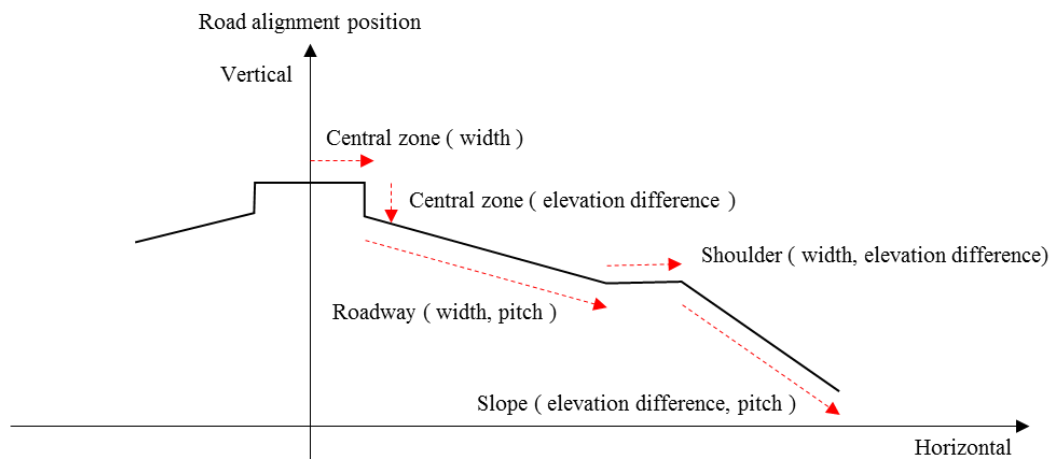


Figure 1. The characteristics of the data model

### 2.1 ELEMENT DEFINITION PATTERN

Element definition pattern was cross section of the roadway, shoulder, width to change the shape of the elements, such as trails and slopes, gradient, is a model that defines the elevation difference, the GradeModel of LandXML1.2 to reference. The image of the element definition pattern is shown in Figure 2.

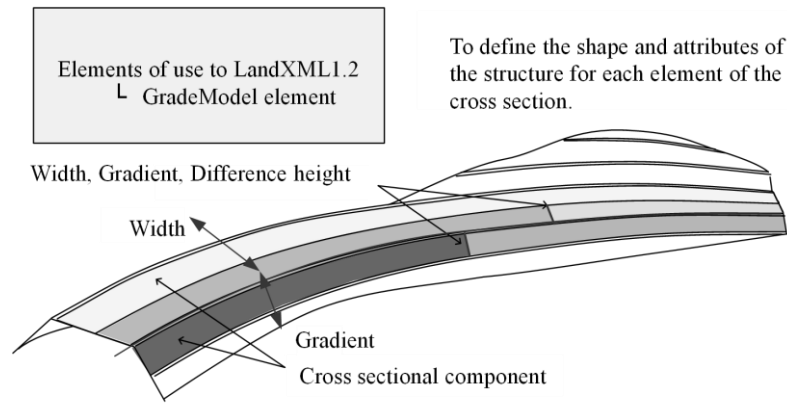


Figure 2. The element definition pattern

### 2.2 CROSS SECTION DEFINED PATTERN

Cross section defined pattern is a model that you added the central zone is a necessary element in the basic design data of the can-shaped management by the total station, roadway, sidewalk, the elements of the shoulder, etc., was referring to the CrossSect of LandXML1.2. The image of the cross-section defined pattern is shown in Figure 3.

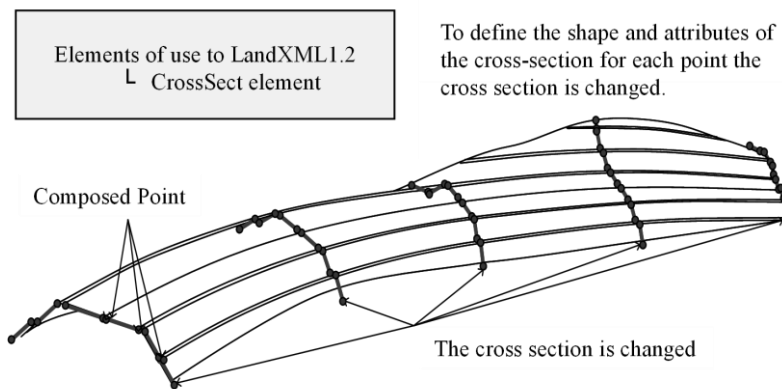


Figure 3. The cross section defined pattern

### 2.3 ADDED ELEMENTS AND ATTRIBUTES

Existing study model describes using the Feature element and desc attribute elements that lack in LandXML1.2 necessary in Japan of road design. It is not necessary to explicitly the concept of road design adds information to be data exchanged using the Feature element. Those who explicitly to add better information as design data using the desc element. The elements and attributes that you added in the Existing study model shown in Table 1.

Table 1. The elements and attributes that you added in the Existing

Destination	Added content
Feature	"Stations of attributes (Cumulative distance, Tangential angle)" as a child of the CgPoint element "Survey point interval" as a child of staEquation element "Super elevation rubbed" as a child of Superelevation element "Formation" as a child of the Cross Section element
desc	Business stage, Note of the coordinate reference system, Notes coordinate point set, The coordinate point note, Constructs information type, Standard-grade, Design traffic volume, Left and right coast division, Linear calculation methods and other notes, The IP-point note, Longitudinal linear notes, Notes of a longitudinal ground line, Business stage of creating the data, Management section, Target coordinates name, Rounding distance, Kind of a cross configuration, Building limit

### 3. EXTENSION OF THE POLICY

In this study, to extend the LandXML1.2 in consideration of the Japan of road design circumstances and the road construction circumstances. Its extension is the following point's policy.

- Existing study model from to extract the elements of the construction production cycle to extend the schema of LandXML1.2
- Existing study model from to modify the schema of LandXML1.2 consider occurs for each business stage of construction production cycle (Surveying, Design, Construction and Maintenance)

### 4. LANDXML1.2 EXTENSION OF THE 3D DESIGN DATA EXCHANGE STANDARD

In this research to create a 3D design data model (hereafter, "This study model") that extends the LandXML1.2 taking into account the "2. Existing study model" and "3. Extension of the policy". This study model is the next extended content and extended result.

#### 4.1 EXTENDED CONTENT

Show enhanced content required for each stage of construction production cycle for this study model.

##### 4.1.1 SURVEYING STAGE

Surveying stage requires the elements of the survey results other than the design shape. LandXML1.2 has a CrossSectSurf elements and ProfSurf element as the element that represents a cross shape and vertical shape of the terrain line. However, since these elements are included in the child element of Alignments elements, not suitable as an element of the surveying results. In this study to define the survey results by adding the Surface elements other than Alignments element.

##### 4.1.2 DESIGN STAGE

Existing study model is to define the cross section in the element definition pattern and cross section defined pattern. However, in Japan the road design is designed with a generally cross-defined pattern. Element definition pattern is difficult to spread it defines a 3D model of the change point of the cross sectional component as a break line. In the present study to abolish the element definition pattern of existing study model. Then, we propose a new cross section defined pattern using a cross sectional component. The new cross-section defined pattern there is a need to define the cross-sectional shape for each cross sectional component (Subgrade, Subbase, Road surface, etc.). The image of the new cross-section defined pattern is shown in Figure 4.

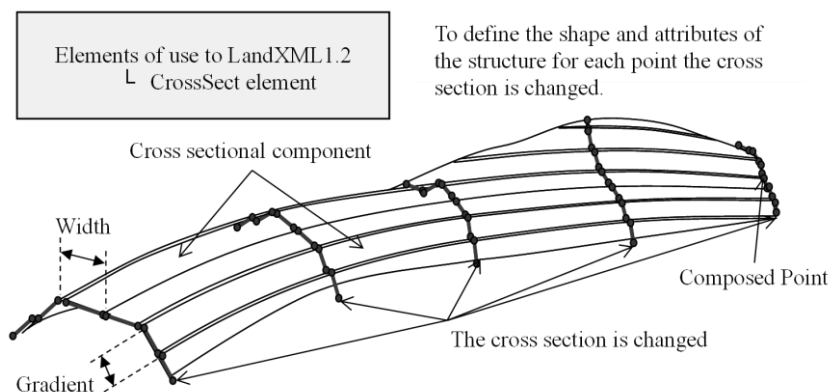


Figure 4. The cross section defined pattern using a cross sectional component

LandXML1.2 is occurs of CrossSects elements that define a set of cross-sectional shape is 0 or 1. Therefore, restoring the number of cross sectional component is mixed in one of CrossSects elements. This lowers the readability of the data. In this study to change occurs of CrossSects element greater than or equal to 0, in order to define a set of cross-sectional shape for different components.

The road design of Japan relaxation curve is using a clothoid. Clothoid is focused on clothoid parameter A, not the length. In this study adds a new attribute of the clothoid parameter A.

##### 4.1.3 CONSTRUCTION STAGE

Construction stage requires the elements and attributes that you have added to the Existing study model in order to cope with the information of the construction, such as "work progress control using the Total Station", which is the principle of from April 2013.

#### 4.1.4 MAINTENANCE STAGE

In the maintenance stage there is a need for elements existing study model has been added to the desc attribute, such as "Meta data for managing the data file" and "Construction gauge needed to perform the interference checking of the road in the 3D space" of This study model.

#### 4.2 EXTENDED RESULT

This study model extends the LandXML1.2 taking into account the "4.1 Extended content", in order to adapt to Japan of road design and existing software. This study model is a list of the different elements and attributes and LandXML1.2 shown in Table 2. And, Figure 6 shows the configuration of the This study model.

Table 2. This study model is a list of the different elements and attributes and LandXML1.2

The element to be added.	The element to add	Description	Occurs	The attributes to add	Description	
Project			1	projectPhase	Current business stage	
				applicationCriterion	The criteria to be applied	
				alignmentRefs	Center linear referencing	
CgPoints	-		0 or more	alignmentRefs	Center linear referencing	
CgPoint			0 or more	sta	Cumulative distance mark	
				tangentDirectionAngle	Tangential angle	
				class	Kind of reference point or benchmark	
Alignments			0 or more	designGmType	Information of the construct	
				classification	Standard, grade	
				trafficVolume	Designed traffic volume	
				side	Left bank, right bank	
Alignment	Interval	Point interval element	0 or more	method	Design calculation method name	
				1	main	Survey point main interval
				sub	Survey point sub interval	
Spiral	-		0 or more	A	Clothoid parameter A	
Superelevation	SVIPnt	Displacement point of superelevation rubbed element	0 or more	side	Position of superelevation	
				vcl	Buffer vertical curve length	
				vcr	Buffer longitudinal song radius	
CrossSects			0 or more	projectPhase	Business stage of the cross-section	
				profAlignRefs	Vertical linear referencing	
				0 or 1	startSta	Start cumulative distance mark
endSta	Exit cumulative distance mark					

CrossSect	-		1 or more	controlSect	Management cross section
				targetPntID	The name of the target coordinates
	Formation	Formation point element	1	clOffset	Distance from the center line
				fhOffset	The difference from the plan high
DesignCrossSectSurf	-		1 or more	xSectType	The type of cross-configuration
				clearance	Building limit
				pavementClass	Pavement type

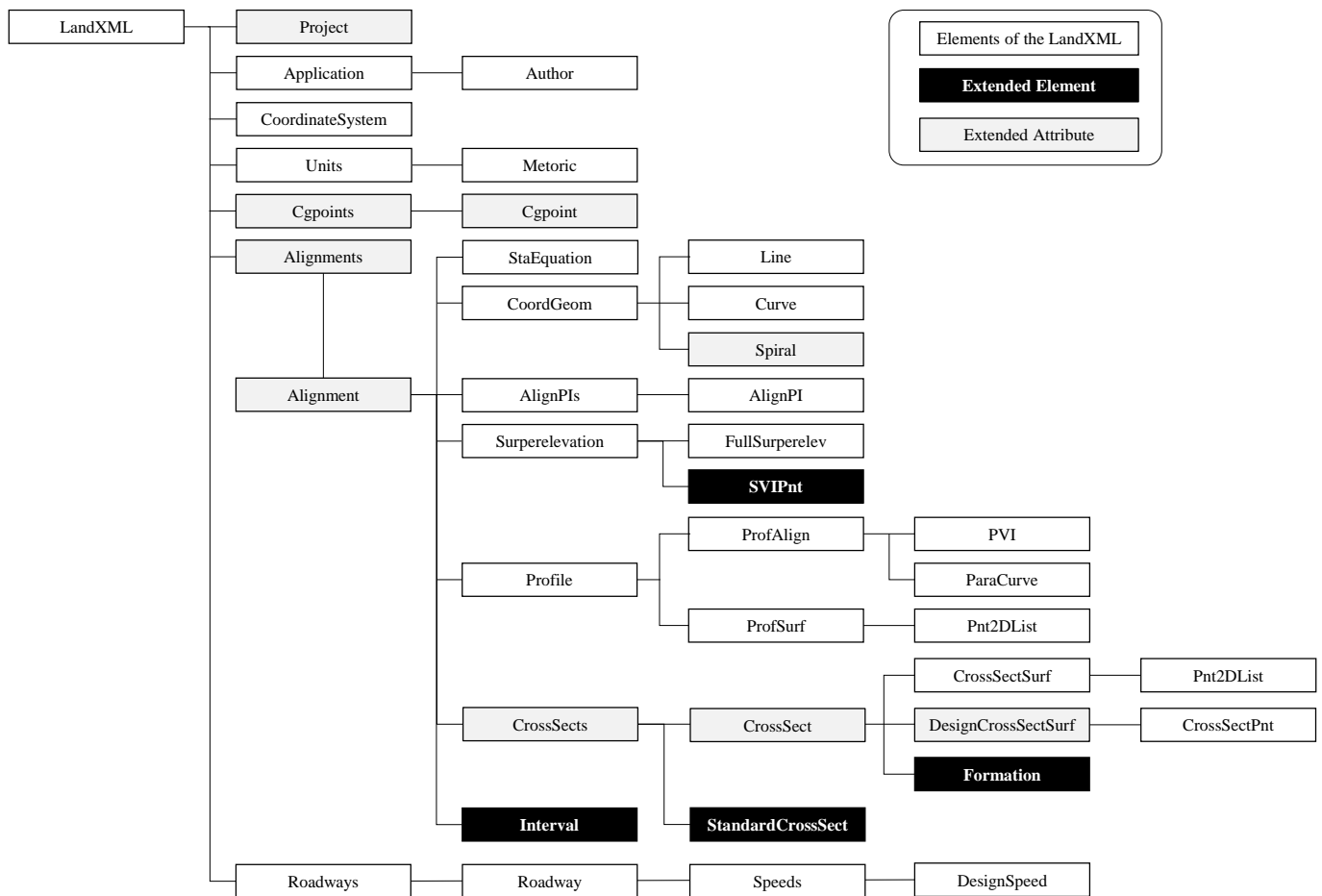


Figure 4. The expanded model of LandXML1.2 with the lacking elements for a 3D design data exchange

#### 4.3 CONSIDERATION

In this study, it was to create a 3D design data suitable to solve the two problems with the Existing study model the authors created construction production cycle in Japan. The next concern is it is in the case of using the 3D design data created in this study in real construction production cycle.

- LandXML is not common in the standard data model but is surveying industry in the road design. Therefore, data exchange to the design stage is concerned by the surveying stage.
- Such as when Alignment of recovery count is present, consider the way of expressing complex road shape is missing.
- River field to design a levee normal and plans normal as Alignment element, but the river center line becomes the Alignment element in the maintenance stage. However, consider the exchange of data using

a different Alignment element is missing.

## 5. CONCLUSIONS

In this study, to extend the LandXML is an international 3D data model. This study model has added an element to the shortage, was created as a data model to be applied to the Japan of road design. And, to modify the required level of each element in the elements, such as construction production cycle that is required in order to represent the data model. Thus it was solved two of the problem (The schema of the limit of LandXML and Ours of the elements of the LandXML) with the Existing study model. And, it revealed the concern to be solved in the case to take advantage of to actually construction production cycle the data model that was created.

In addition, this model extended by using the existing LandXML1.2, which makes it software with relatively easy implementation. There have been various data models for 3D structures of road and river dikes, but the standardization of the entire model is difficult due to differences in use, and the actual usage has not been enhanced. We believe that our results can be foundational resources for standard product models which will lead to active investigation hereafter. We plan to continue the investigation on the operational rules and usage method of this data model as well as to resolve the concern.

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