1. A STUDY OF TRANSLATOR BETWEEN AP203 AND VRML FOR DESIGN INFORMATION OF STEEL HIGHWAY BRIDGES

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【Abstract】 It is necessary to standardize the electronic information in lifecycle of steel highway bridges. Product Data Models (PDMs) have been constructed using STEP/AP203. Now, there are no browsers for AP203. Product Data Models are visualized by using VRML. PDMs are managed by AP203 and VRML. VRML are utilized for visualizing and displaying PDMs in three-dimension. The translator between AP203 and VRML was developed for the shape information of composing members in plate girder bridge.

【Keywords】 Steel Highway Bridges, Design Information, Product Data Model, STEP/AP203, VRML

1. INTRODUCTION

Highway bridges have the stages of planning, survey, design, estimation, construction, and maintenance. It is necessary to exchange, connect, and share information accurately and smoothly in each stage of life cycle Information of steel highway bridges must be standardized over lifecycle. Three-dimensional information of real structure shape is adopted to communicate accurately. It is necessary to collect and analyze information of each stage for standardizing 3D-information. Common standardization is defined, and developed as Product Data Model (PDM) [1]-[6].

The environment that design engineers can design the plate girder bridges using PDMs in three-dimension is constructing[7]-[9]. First, three-dimensional Product Data Models (3D-PDMs) had been constructed. The design information that 3D-PDMs have is three-dimensional shape information, technology information of composing members, production information for fabricating and inspecting members, management information of addition, amendment, and deletion, and property information. STEP/AP203 (ISO10303-203) [10]-[17] was applied to construct PDMs. Next, VRML (ISO/IEC14772) has visualized PDMs. The necessary information was 3D-shape information. The system that plate girder bridges are assembling using visualized PDMs for preliminary design phase. The output file format of this system is only VRML file format. The members are managed by AP203 and VRML before design. However, the plate girder bridges are managed by VRML only after design. AP203-data and VRML-data are not connected. The translator from VRML-data into AP203-data is necessary to utilize VRML-data after design as AP203-data.

There are no browsers to display AP203-data on Web Page. In this case, VRML is adopted to browse AP203-data. It is necessary to develop the translator from AP203-data to VRML-data. STEP is utilized frequently in mechanical engineering. The systems that translate from CAD-data into AP203-data are developed [18]-[21]. STEP is just adopted in civil engineering. AP203 and VRML are not utilized in civil engineering. The translator between AP203 and VRML is not developed in all industries.

In this paper, 3D-shape information of plate girder bridges is exchanged with both directions. The translator from AP203-data into VRML-data is developed. And, the translator from VRML-data into AP203-data is developed. Shape information of

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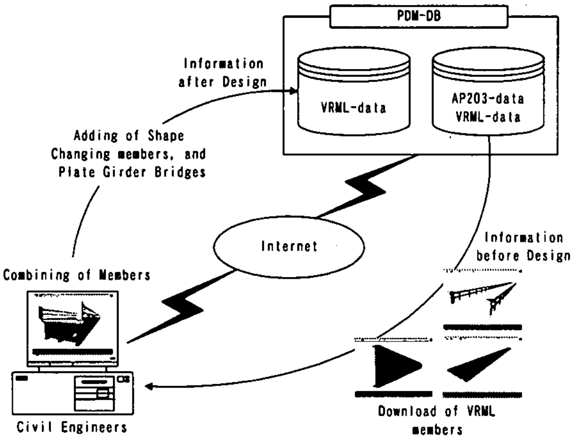

Fig.1 Assembling System of Plate Girder Bridges

design information in plate girder bridges is intended. It is necessary information to visualize the members in three-dimension. The environment that AP203 is utilized for exchanging and connecting the 3D information and VRML is applied for displaying and browsing AP203-data is realized.

2. EXISTING SYSTEM

2.1 CONSTRUCTION OF PRODUCT DATA MODELS

In the existing paper, design information of plate girder bridges have been standardized. Product Data Models (PDMs) have been constructed applying STEP/AP203. AP203 can deal with three-dimensional shape and configuration management information of products. By using AP203, design information of plate girder bridges can be represent and manage.

Product Data Models Database (PDM-DB) has been constructed to mange PDMs. PDM-DB has been utilized by many civil engineers on the Internet. The civil engineers can search PDMs on the web page, and display and download AP203 files from the database server.

2.2 ASSEMBLING SYSTEM OF PLATE GIRDER BRIDGES

PDMs of plate girder bridges represented by AP203 have been visualized by VRML. The system that assembly plate girder bridges using visualized 3D members has been developed. It was developed to confirm the bridge shape on the stage of preliminary design. The assembling system of plate girder bridges using PDM-DB is shown Fig.1. The system can be outputted assembling bridges as VRML file format. The bridges of VRML can represent on web page.

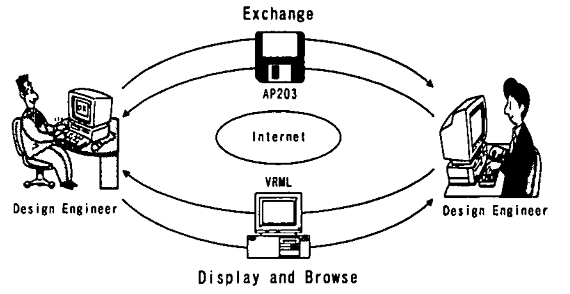

Fig.2 Exchanging of AP203-data and VRML-data

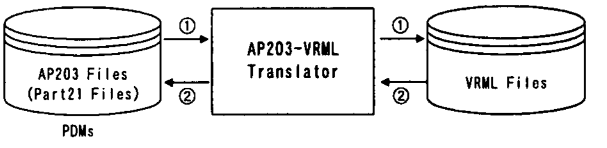

Fig.3 Development of Translator

3. DEVELOPMENT OF TRANSLATOR BETWEEN AP203 AND VRML

In the existing paper, design information of plate girder bridges is standardized and managed by AP203. Now, there are no browsers for product information represented by AP203 on web page. We think that the same PDMs are managed by AP203 and VRML. AP203 is utilized for exchange, connect, share, and reuse the information over lifecycle of bridges. VRML is utilized for visualize and represent the PDMs in three-dimension. The data flow of AP203 and VRML is shown in Fig.2.

3.1 OUTLINE OF TRANSLATOR

The same PDMs of shape information in highway bridges is represented and managed by AP203 and VRML. It is necessary to connect between two file formats for managing the same PDMs with each file formats. The translator between AP203 and VRML

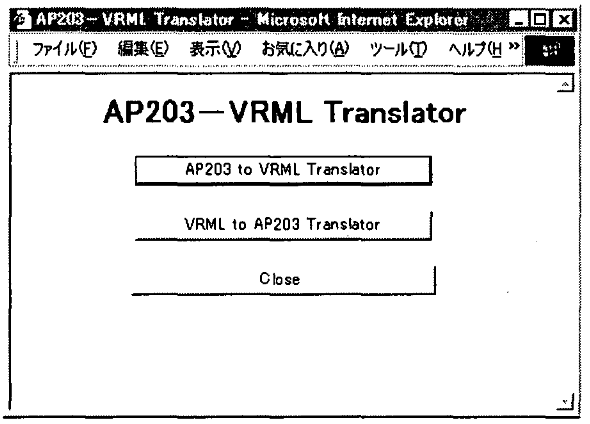

Fig.4 Main Window of Translator

is developed for connecting the two file formats. Development image of translator is shown in Fig.3. AP203-VRML translator is composed of AP203 to VRML translator that is translated from AP203-data into VRML-data and VRML to AP203 translator that is translated from VRML-data into AP203-data.

The main window of translator is shown in Fig.4. The civil engineers select the using system and execute. The flow of translator that AP203-data is translated into VRML-data and VRML-data is translated into AP203-data is shown in Fig.5. The design engineers access to PDM-DB through the Internet. They acquire the necessary PDMs (AP203-data) from bridge members DB. Because PDMs is parts library, the shape must be changed. PDMs are translated into VRML-data using AP203-VRzL translator. The size of member is changed using assembling system of plate girder bridges. The designed members can be visualized. By using AP203, shape information of member can be exchange, connect, share and reuse.

3.2 AP203 TO VRML TRANSLATOR

AP203 to VRML translator is translated from AP203-data of steel highway bridge's composing members into VRML-data. AP203-data is visualized and presented on the web. The civil engineers can browse shape information of members represented as PDM. In this paragraph, the characteristic of AP203-data is analyzed. The method that AP203 is corresponding to VRML is explained.

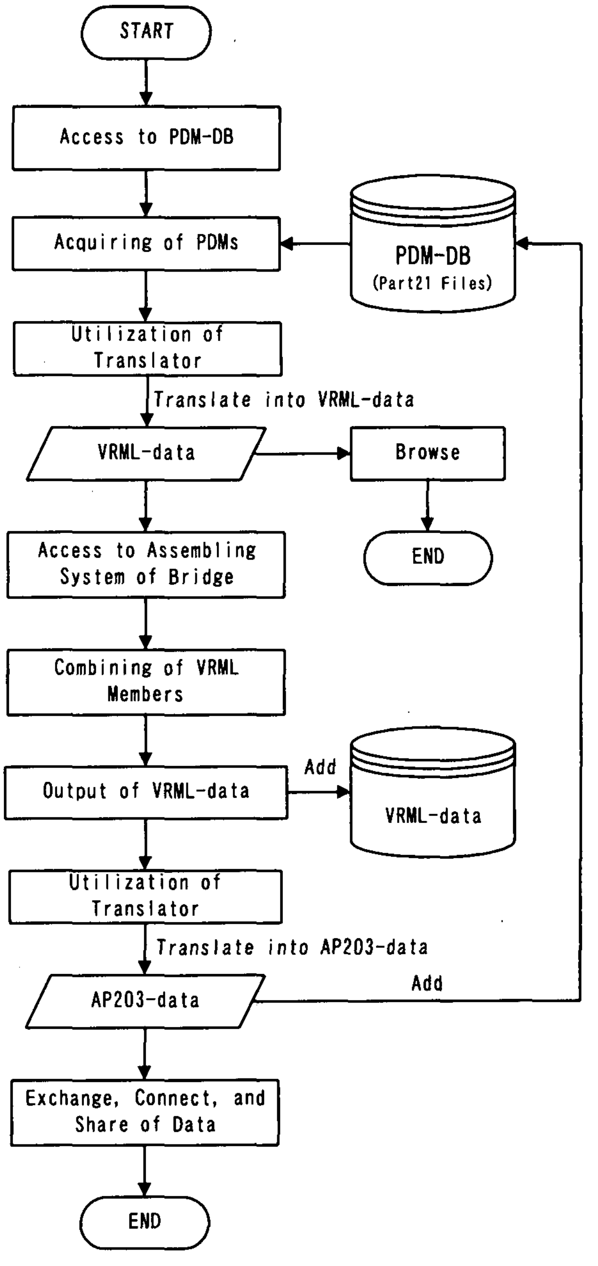

Fig.5 Flow of Data Exchange Using Translator

3.2.1 CHARACTERISTIC OF AP203-DATA

The scope of AP203 is three-dimensional members based on configuration controlled management and design of assembly. AP203 can deal with shape information and configuration controlled information of product. Shape information can display outline of design objects. Configuration controlled information can represent information of product lifecycle. Alias Studio 8.5 (Alias Wavefront Inc.) was used to make PDMs and described members of plate girder bridges. AP203-data is outputted. AP203 is defined sixth conformance class (CC) shown in Fig.6. In the

CC1 : Configuration management information (without shape)
CC2 : CC1, geometrically_bounded_wireframe_shape_representation, and geometrically_bounded_surface_shape_representation
CC3 : CC1, edge_based_wireframe_shape_representation, and shell_based_wireframe_shape_representation
CC4 : CC1 and manifold_surface_shape_representation
CC5 : CC1 and faceted_brep_shape_representation
CC6 : CC1 and advanced_brep_shape_representation

Fig.6 Conformance Class of AP203

present paper, CC2 is intended for the system.

STEP defines the Part21 file format that is the file-exchange standard. The CAD data converted into STEP data format is described as STEP entities in data paragraph of Part21 file. In this system, AP203 entities is corresponded into VRML nodes and translated into VRML file.

3.2.2 DEVELOPMENT OF TRANSLATOR

Shape information AP203-data (Part21 file) of simple top flange is shown in Fig.7. In this paragraph, AP203-data of this top flange is used as example. Configuration management information of product corresponding to CC1 is described from #60 to #400 line. 3D shape information is described from #470 to #1510 line. Because this system is intended for shape information of members, it uses from #470 line. Shape information described from #470 to #1510 is translated from AP203 entities represented top flange into Box node of VRML. Geometrically_bounded_surface_shape_representation of #470 line represent product shape and part of product shape by surface_geometry without topology. It is represented by one or several geometric_set entity. This entity shows CC2. The translator inspects whether the file is AP203-data of CC2 by this entity. Geometric_set entity in #490 line is as set of geometry data.

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#470 = GEOMETRICALLY_BOUNDED_SURFACE_SHAPE_REPRESENTATION(
'Surface Model',(#490),#50);
#480 = SHAPE_REPRESENTATION_RELATIONSHIP('Mixed Model',
'Surface Relationship',#410,#470);
#490=GEOMETRIC_SET('Alias Surface
Model',(#500,#670,#840,#1010,#1180,#1350));
#500 = (BOUNDED_SURFACE()
B_SPLINE_SURFACE(3,3,((#510,#520,#530,#540),(#550,#560,#570,#580),(#590,#600
,#610,#620),(#630,#640,#650,#660)),.UNSPECIFIED.,.U.,.U.,.U.)
B_SPLINE_SURFACE_WITH_KNOTS((4,4),(4,4),(-1.,0.),(0.,1.),.UNSPECIFIED.)
GEOMETRIC_REPRESENTATION_ITEM()
RATIONAL_B_SPLINE_SURFACE((((1.,1.,1.,1.),(1.,1.,1.,1.),(1.,1.,1.,1.),(1.,1.,1.,1.)))
REPRESENTATION_ITEM('surface') SURFACE());
#510 = CARTESIAN_POINT('CVs',(21.,-1500.,-1.6));
#520 = CARTESIAN_POINT('CVs',(21.,-1500.,-0.533333333333333));
#530 = CARTESIAN_POINT('CVs',(21.,-1500.,0.533333333333333));
#540 = CARTESIAN_POINT('CVs',(21.,-1500.,1.6));
#550 = CARTESIAN_POINT('CVs',(21.,-500.,-1.6));
#560 = CARTESIAN_POINT('CVs',(21.,-500.,-0.533333333333333));
#570 = CARTESIAN_POINT('CVs',(21.,-500.,0.533333333333333));
#580 = CARTESIAN_POINT('CVs',(21.,-500.,1.6));
#590 = CARTESIAN_POINT('CVs',(21.,500.,-1.6));
#600 = CARTESIAN_POINT('CVs',(21.,500.,-0.533333333333333));
#610 = CARTESIAN_POINT('CVs',(21.,500.,0.533333333333333));
#620 = CARTESIAN_POINT('CVs',(21.,500.,1.6));
#630 = CARTESIAN_POINT('CVs',(21.,1500.,-1.6));
#640 = CARTESIAN_POINT('CVs',(21.,1500.,-0.533333333333333));
#650 = CARTESIAN_POINT('CVs',(21.,1500.,0.533333333333333));
#660 = CARTESIAN_POINT('CVs',(21.,1500.,1.6));
#670 = (BOUNDED_SURFACE()
B_SPLINE_SURFACE(3,3,((#680,#690,#700,#710),(#720,#730,#740,#750),(#760,#770
,#780,#790),(#800,#810,#820,#830)),.UNSPECIFIED.,.U.,.U.,.U.)
B_SPLINE_SURFACE_WITH_KNOTS((4,4),(4,4),(0.,1.),(0.,1.),.UNSPECIFIED.)
GEOMETRIC_REPRESENTATION_ITEM()
RATIONAL_B_SPLINE_SURFACE((((1.,1.,1.,1.),(1.,1.,1.,1.),(1.,1.,1.,1.),(1.,1.,1.,1.)))
REPRESENTATION_ITEM('surface') SURFACE());
#680 = CARTESIAN_POINT('CVs',(-21.,1500.,1.6));
#690 = CARTESIAN_POINT('CVs',(-21.,500.,1.6));
#700 = CARTESIAN_POINT('CVs',(-21.,-500.,1.6));
#710 = CARTESIAN_POINT('CVs',(-21.,-1500.,1.6));
#720 = CARTESIAN_POINT('CVs',(-21.,1500.,0.533333333333333));
#730 = CARTESIAN_POINT('CVs',(-21.,500.,0.533333333333333));
#740 = CARTESIAN_POINT('CVs',(-21.,-500.,0.533333333333333));
#750 = CARTESIAN_POINT('CVs',(-21.,-1500.,0.533333333333333));
#760 = CARTESIAN_POINT('CVs',(-21.,1500.,-0.533333333333333));
#770 = CARTESIAN_POINT('CVs',(-21.,500.,-0.533333333333333));
#780 = CARTESIAN_POINT('CVs',(-21.,-500.,-0.533333333333333));
#790 = CARTESIAN_POINT('CVs',(-21.,-1500.,-0.533333333333333));
#800 = CARTESIAN_POINT('CVs',(-21.,1500.,-1.6));
#810 = CARTESIAN_POINT('CVs',(-21.,500.,-1.6));
#820 = CARTESIAN_POINT('CVs',(-21.,-500.,-1.6));
#830 = CARTESIAN_POINT('CVs',(-21.,-1500.,-1.6));
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Fig.7 AP203-data of Top Flange

(#500, #670, #840, #1010, #1180, #1350) lines represent top flange is consisted of six surfaces, and the surfaces are connected. There are nodes that can translate geometric_set in VRML. The translator reads in geometric_set entity, and recognizes that six lines are connected. The translator is designed that can link the each line of #500, #670, #840, #1010, #1180, and #1350. #500 line represents one surface of six surfaces consisting of top flange. Bounded_surface is

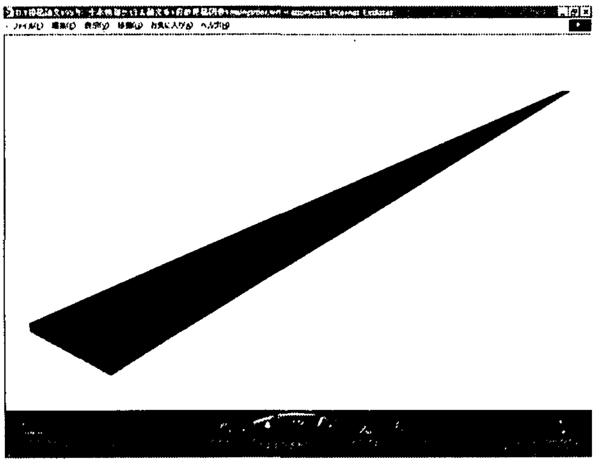

Fig.8 VRML of Top Flange

the entity representing a curved surface with boundary. (#510, #520, #530, #540) is a set, and represent four points. Cartesian_point entity of #510 line is represented the straight coordinate point. In order to translate into Box node, the translator calculates the distance of x, y, z coordinate in (#510, #520, #530, #540), (#550, #560, #570, #580), (#590, #600, #610, #620), (#630, #640, #650, #660) consisting of surface. The translator extracts only necessary points consisting a rectangular solid. It selects the three points of #510, #630, #660 lines on yz surface. It calculates the distance of x direction for Box node. It selects the object surface of #500 line with respect to x direction. It compares a mark of x coordinate and extracts #680 line of cartesian_point to plane of symmetry. It extracts four points, and calculates the distance among each coordinates. The width, height, and depth are calculated, and the rectangular solid is made. The translator is considered coordinate direction, and is translated into Box node. AP203-data of top flange in Fig.7 is translated into VRML-data by using this system. And Fig.8 shows the shape on web browser. Civil engineers can browse the shape of member visualized in three-dimension.

3.3 VRML TO AP203 TRANSLATOR

VRML is utilized to represent the three-dimensional shape. It is difficult to exchange, connect, share, and reuse the design information in VRML. The system that is translated from VRML-data into AP203-data (PDM) is developed. By translating into AP203-data, the environment that can exchange, connect, and share the three-dimensional shape information of members smoothly is constructed. In this paragraph, the structure of VRML-data is analyzed. The method that is corresponded AP203 entities is described.

3.3.1 CHARACTERISTIC OF VRML

VRML is composed of five elements: header, comment, node field, prototype, and route. Nodes and fields are the necessary information in order to translate the 3D shape information of composing members for plate girder bridges into AP203-data. They represent the code of 3D graphics of figure, characteristic, and color. VRML is the gather of nodes. The system translates each node into AP203 entities. VRML ignores the blank and is not depended on a physical new line. It distinguishes a capital letter and a small letter.

The system is developed to consider their structure and to translate into AP203-data. Because simple members are used, nodes that represent geometric shape are utilized. VRML nodes are shown in Table.1 and

Table.1 Using VRML Nodes and Fields

node	field
Transform	translation
	rotation
	scale
	children
	center
	bboxSize
Shape	appearance
	geometry
Box	size
Cone	bottomRadius
	height
Cylinder	radius
	height
Sphere	radius

Table.2 Using AP203 Entities

	entities
point	cartesian_point
surface	bounded_surface
	b_spline_surface
	b_spline_surface_with_knots
	rational_b_spline_surface
	surface
set	geometric_set
	geometrically_bounded_surface_shape_representation
relation	shape_representation_relationship
	geometric_representation_item
	representation_item
	representation
	shape_representation
	shape_definition_representation

```
#VRML V2.0 utf8
#Top flange
Transform{
  translation 0.0 -0.216 0.0
    children[
      DEF TFLANGE Shape{
        appearance Appearance{
          material Material{
            diffuseColor 1 0 0
          }
        }
            geometry Box{ size 30.0 0.030 0.40 }
      }
    ]
}
#Web plate
Transform{
  translation 0.0 -1.232 0.0
    children[
      DEF WEB Shape{
        appearance Appearance{
          material Material{
            diffuseColor 1 0 0
          }
        }
        geometry Box{ size 30.0 2.0 0.01 }
      }
    ]
}
#Bottom flangea
Transform{
  translation 0.0 -2.247 0.0
    children[
      DEF BFLANGE Shape{
        appearance Appearance{
          material Material{
            diffuseColor 1 0 0
          }
        }
        geometry Box{ size 30.0 0.032 0.42 }
      }
    ]
}
```

Fig.9 VRML-data of Main Girder

AP203 entities are shown in Table.2. Nodes that can use are prepared, and the system corresponding to AP203 is developed.

3.3.2 DEVELOPMENT OF TRANSLATOR

The system that translates VRML-data of plate girders' members into AP203-data is developed. VRML-data of main girder shown in Fig.9 and Fig.10 is translated into AP203-data shown in Fig.11. Line one of Fig.9 declares that the file is VRML file. And language specification is version 2.0. A # sign describes that the line is the comment. The translator ignores the comment line. Transform node can execute the parallel movement by translation field and the turn by rotation field. The translator moves the coordinate, and reads in shape node representing shape information. And it is translated into AP203-data. Geometrically_bounded_surface_shape_representation entity representing surface without topology is described in translated AP203-data.

Shape node represents the basic shape in VRML. Shape information of member is composed after this line. Box node represents width, height, and depth of a rectangular solid. These numerical data is translated

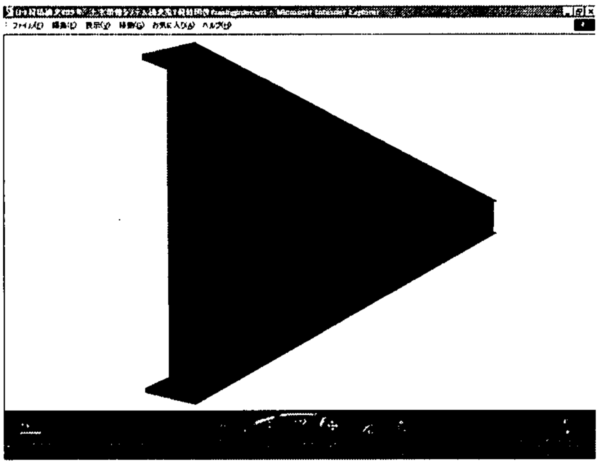

Fig.10 VRML of Main Girder

into cartesian_point entity in AP203. The translator calculates the distance from the origin to width, height, and depth of the rectangular solid. And it decides the top coordinate considering translation field. The sixteen cartesan_point entities are necessary to represent one surface. The translator calculates the sixteen points considering each distance. Each surface is calculated as the same. The gather of six surfaces is represented by geometric_set entity.

The translator is developed by these method, and is translated VRML-data into AP203-data. Shape information of members described by VRML can be exchange, connect, share, and reuse using AP203.

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#470 = GEOMETRICALLY_BOUNDED_SURFACE_SHAPE_REPRESENTATION(
'Surface Model',(#490),#50);
#480 = SHAPE_REPRESENTATION_RELATIONSHIP('Mixed Model',
'Surface Relationship',#410,#470);
#490=GEOMETRIC_SET('Alias Surface Model',
(#500,#670,#840,#1010,#1180,#1350));
#500=(BOUNDED_SURFACE()B_SPLINE_SURFACE(3,3,((#510,#520,#530,#540),
(#550,#560,#570,#580),(#590,#600,#610,#620),(#630,#640,#650,#660)),.UNSPECIFIE
D.,.U.,.U.,.U.)
B_SPLINE_SURFACE_WITH_KNOTS((4,4),(4,4),(-1.,0.),(0.,1.),.UNSPECIFIED.)
GEOMETRIC_REPRESENTATION_ITEM()
RATIONAL_B_SPLINE_SURFACE(((1.,1.,1.,1.),(1.,1.,1.,1.),(1.,1.,1.,1.),(1.,1.,1.,1.)))
REPRESENTATION_ITEM('surface') SURFACE());
#510 = CARTESIAN_POINT('CVs',(-1500.0, -20.0, 1.5));
#520 = CARTESIAN_POINT('CVs',(-1500.0, -20.0, 0.50));
#530 = CARTESIAN_POINT('CVs',(-1500.0, -20.0, -0.50));
#540 = CARTESIAN_POINT('CVs',(-1500.0, -20.0, -1.5));
#550 = CARTESIAN_POINT('CVs',(-500.0, -20.0, 1.5));
#560 = CARTESIAN_POINT('CVs',(-500.0, -20.0, 0.50));
#570 = CARTESIAN_POINT('CVs',(-500.0, -20.0, -0.50));
#580 = CARTESIAN_POINT('CVs',(-500.0, -20.0, -1.5));
#590 = CARTESIAN_POINT('CVs',(500.0, -20.0, 1.5));
#600 = CARTESIAN_POINT('CVs',(500.0, -20.0, 0.50));
#610 = CARTESIAN_POINT('CVs',(500.0, -20.0, -0.50));
#620 = CARTESIAN_POINT('CVs',(500.0, -20.0, -1.5));
#630 = CARTESIAN_POINT('CVs',(1500.0, -20.0, 1.5));
#640 = CARTESIAN_POINT('CVs',(1500.0, -20.0, 0.50));
#650 = CARTESIAN_POINT('CVs',(1500.0, -20.0, -0.50));
#660 = CARTESIAN_POINT('CVs',(1500.0, -20.0, -1.5));
#670=(BOUNDED_SURFACE()B_SPLINE_SURFACE(3,3,((#680,#690,#700,#710),(#7
20,#730,#740,#750),(#760,#770,#780,#790),(#800,#810,#820,#830)),.UNSPECIFIED.,.
U.,.U.,.U.)
B_SPLINE_SURFACE_WITH_KNOTS((4,4),(4,4),(0.,1.),(0.,1.),.UNSPECIFIED.)
GEOMETRIC_REPRESENTATION_ITEM()
RATIONAL_B_SPLINE_SURFACE(((1.,1.,1.,1.),(1.,1.,1.,1.),(1.,1.,1.,1.),(1.,1.,1.,1.)))REPR
ESENTATION_ITEM('surface') SURFACE());
#680 = CARTESIAN_POINT('CVs',(-1500.0, 20.0, 1.5));
#690 = CARTESIAN_POINT('CVs',(-1500.0, 20.0, 0.50));
#700 = CARTESIAN_POINT('CVs',(-1500.0, 20.0, -0.50));
#710 = CARTESIAN_POINT('CVs',(-1500.0, 20.0, -1.5));
#720 = CARTESIAN_POINT('CVs',(-500.0, 20.0, 1.5));
#730 = CARTESIAN_POINT('CVs',(-500.0, 20.0, 0.50));
#740 = CARTESIAN_POINT('CVs',(-500.0, 20.0, -0.50));
#750 = CARTESIAN_POINT('CVs',(-500.0, 20.0, -1.5));
#760 = CARTESIAN_POINT('CVs',(500.0, 20.0, 1.5));
#770 = CARTESIAN_POINT('CVs',(500.0, 20.0, 0.50));
#780 = CARTESIAN_POINT('CVs',(500.0, 20.0, -0.50));
#790 = CARTESIAN_POINT('CVs',(500.0, 20.0, -1.5));
#800 = CARTESIAN_POINT('CVs',(1500.0, 20.0, 1.5));
#810 = CARTESIAN_POINT('CVs',(1500.0, 20.0, 0.50));
#820 = CARTESIAN_POINT('CVs',(1500.0, 20.0, -0.50));
#830 = CARTESIAN_POINT('CVs',(1500.0, 20.0, -1.5));
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Fig.11 AP203-data of Main Girder

4. CONCLUSION

In this research, the translator of three-dimensional shape information between AP203 and VRML was developed to design plate girder bridges using PDMs in three-dimension. Shape information of PDMs can treat. It is necessary information in order to deal with the members in 3D. By developing AP203-VRML translator, the environment that AP203 is utilized for exchange, connect, and share shape information of plate girder bridges, VRML is utilized for display and browse AP203-data is realized.

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