STUDY ON 3D STEEL BRIDGE PRODUCT MODEL FOR QUANTITY SURVEY IN JAPAN

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Agenda

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- Vision of MLIT CIM
- Objectives of JACIC
- Existing studies

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What's abbreviation "CIM"

■Building Information Modeling (BIM)

■ Civil, Infrastructure
- BIM for Civil Engineers
- BIM for Infrastructure
- Civil Infrastructure Modeling (CIM)
- Civil Integrated Management (CIM)
- infraBIM

■In Japan
- Civil Information Modeling/Management (CIM)

■Computer science, Mechanical engineering
- Computer Integrated Manufacturing (CIM)

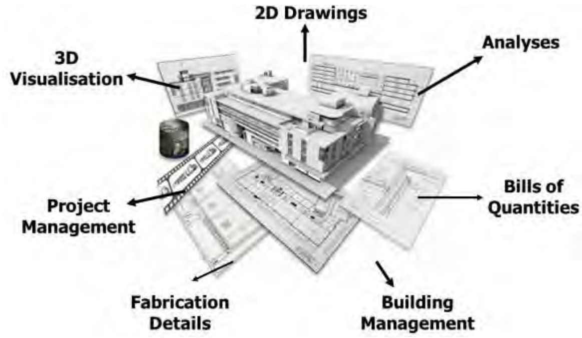


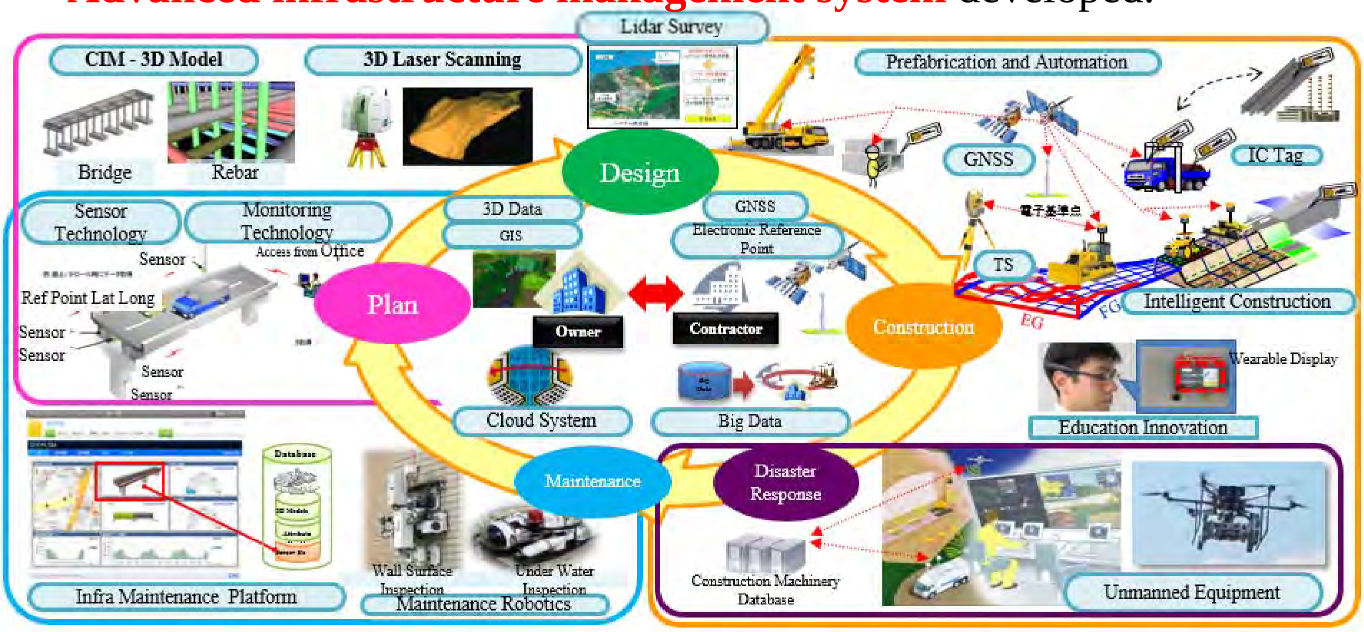
Figure 1. BIM Image

Figure 2. CIM Image

Figure.1 ; History of Building Information Modelling < http://codebim.com/resources/history-of-building-information-modelling/ >

Vision of MLIT CIM

- Promoting utilization of **3D Product Model** throughout lifecycle.
- Data acquisition technology such as **3D Laser Scanner and UAV etc.**
- **Advanced infrastructure management system** developed.



Objectives of JACIC

JACIC has been engaged in computerization of the construction field.

- JACIC (Japan Construction Information Center Foundation) was founded in 1985 under authority of Ministry of Construction, Japan.
- The aim of the organization is to promote the application of Information and Communication Technology for the sake of efficient and reliable execution of construction project.
- Since then, JACIC has been working in various activities as a public organization in neutral stand point.
  - Promotion of arts, sciences and technology.
  - Standardization
  - Environmental preservation by utilization of resources.
  - Improvement in information security.
  - Stable provision of information.
  - Research and development of information systems
  - Education and dissemination of computerizations.

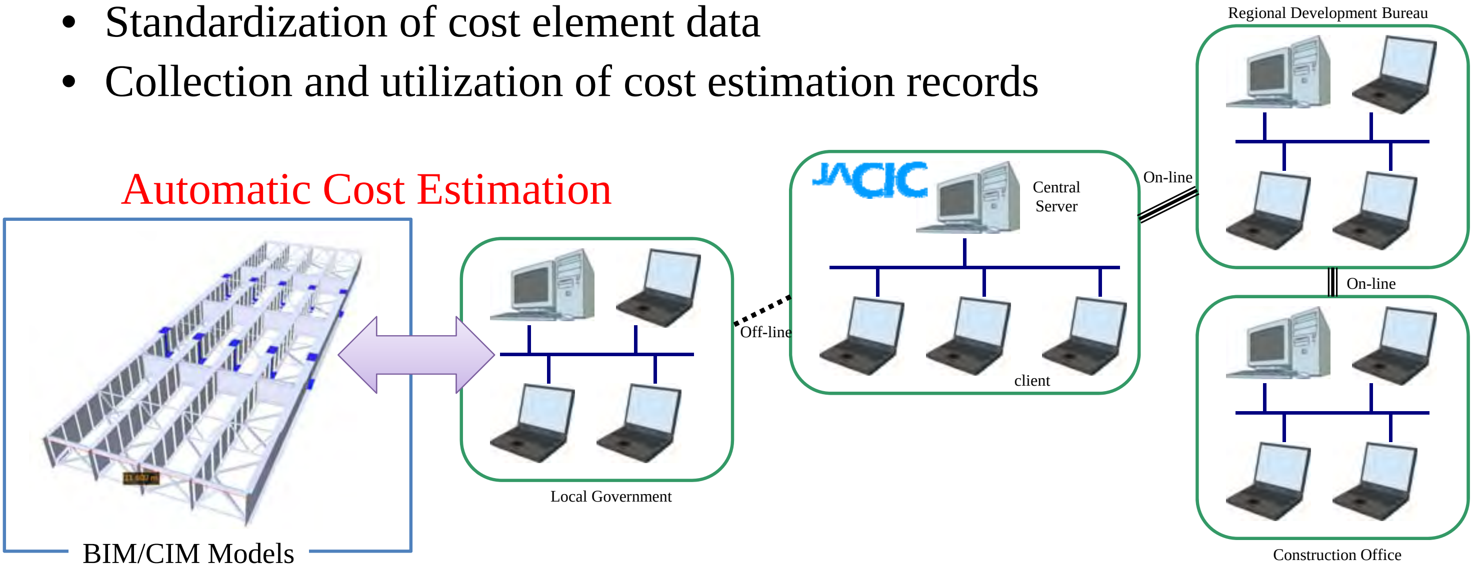
JACIC
The Key-Base Information Station
for the Construction Industry to pave way for the Future
Japan Construction Information Center
General Incorporated Foundation

Cost Estimation Support Service

New Cost Estimation System for Public Works Projects

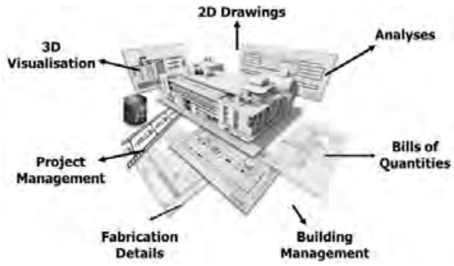
- Standardized classification of construction work type
- Improved and easy operation
- Standardization of cost element data
- Collection and utilization of cost estimation records

Automatic Cost Estimation



Existing studies（with BIM/CIM）

- According to the study of management method for construction projects conducted by Russel et al (2015).
- 50 international construction projects use one or more systemic project control mechanisms BIM, EVM, and Location Based Management (LBM).
- Of that sub-set, the document also reports that 38.1% use two and 23.8% use all three for project control.
- However, there are no existing studies focusing on the relationship between 3D product modeling and <u>government contract unit / project management.</u>



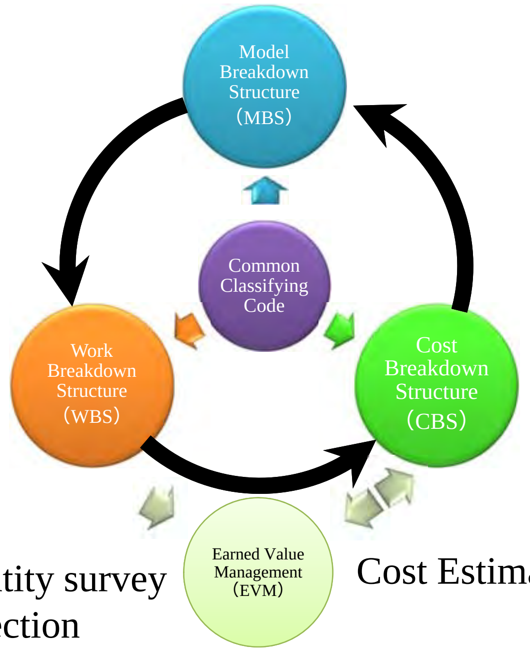
BIM Model for a project.

BIM/CIM Models for Government multiple projects.

Quantity Survey by MLIT

- The MLIT specifies “Civil Engineering Construction Quantity Survey Outlines and Guidelines (MLIT, FY2017 Edition)”.
- This document specifies items required to calculate costs of the relevant construction project.
- Calculate costs are needed to be registered on design specifications when a contractor undertakes a civil engineering project under direct control of the MLIT.

BIM/CIM Model Elements



- Quantity survey
- Inspection

Cost Estimation

Work Item Standardization

- In order to re-evaluate the traditional quantity survey system and create a unified / consistent scheme.
- The MLIT is currently working on the "New Estimating System of Public Works" to create a new quantity survey framework.
- As a part of this process, work items are standardized to calculate direct construction costs.

Table 1. Hierarchical layer (levels) for work item standardization

Level	Identifier	Content
Level 0	Business Classification	Classification based on budgeting system and business operations.
Level 1	Construction Classification	Level 0 divided to address work order lot and orderer.
Level 2	Work Item	General term for a series of operations required to construct certain structural elements (part of level 1 elements).
Level 3	Class	Level classification to connect level 2 and 4 to clarify the overall standardization system.
Level 4	Subdivision	Level to indicate units and contract units that are basic derivative unit or temporary structure unit of the relevant construction work.
Level 5	Specification	Objective information on materials, standards and contract specified conditions for level 4 configuration components.
Level 6	Quantity Survey Element	Level 4 cost calculation components generally not disclosed in contract.

Quantity Survey of Work Items using 3D Product Modeling

- The "Quantity Survey Items and Classification Conditions" only caters for quantity surveying using 2D drawings.
- Therefore, in order to perform quantity surveying of work items using 3D product models, it is essential to prepare a separate "Quantity Survey Items and Classification Conditions for 3D Product Model" in order to ensure quantity survey results match that of the traditional method.
- Table 2 indicates quantity survey items and classifications for the 3D product model.

Table 2. Quantity survey items and classification conditions

Classification		Conditions
Geometric Information		●: Production of 3D geometry required. (Required condition) ○: Uses 3D geometry required to meet conditions. (Sufficient condition) △: Production of 3D geometry required depending on conditions. x: Production of 3D geometry not required
Attribute Information	Quantity Calculation	A: Quantity survey directly from 3D geometry. B: Quantity survey indirectly from 3D geometry. C: Quantity survey from 3D geometry depending on conditions. D: No 3D geometry required (applicability information only).
	Unit	Quantity survey unit
	Specification, Format	○: Required for quantity survey. x: Not required for quantity survey.

Quantity Survey of Work Items using 3D Product Modeling

■ Quantity survey items and Classification (Steel bridge upper deck)

- Table 3 shows conditions.
- Table 4 shows for the 3D product model.

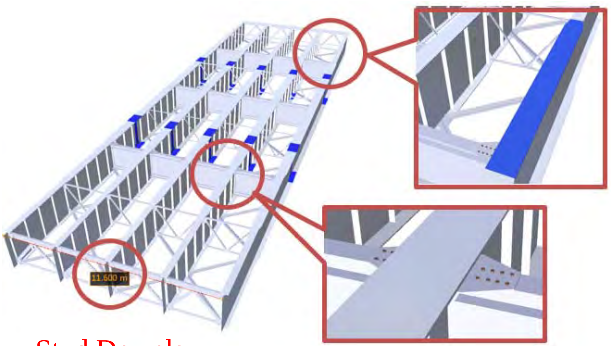


Table 3. Quantity survey items and classification conditions (steel bridge upper deck)

Construction Classification (Level 1)	Work Item (Level 2)	Class (Level 3)
Steel Bridge Upper Deck	Shop Fabrication	Girder Fabrication

Level 4 (Subdivision)	Level 5 (Specification)	Quantity Survey Unit	Unit for Summary Chart
Manufacturing	Steel Material Standards	t	t
Bolts / Nuts	Bolts / Nuts Type	Pairs	Pairs
Stud Dowels	Diameter / Length	Pcs	Pcs

Table 4. Quantity survey items and classifications for 3D product model (steel bridge upper deck)

Classification / Item	Geometric Information	Attribute Information		
		Quantity Calculation	Unit	Specification
Manufacturing	●	A	t	○
Bolt / Nut	△	B	Pairs	○
Stud Dowels	△	B	Pcs	○

Evaluation of Effectiveness

- By outputting the government quantity survey data obtained from the 3D product model of the bridge structure.
- The bridge structure is generated in accordance with the newly defined data structure, the potential of EVM coordination was evaluated.
- The newly defined 3D product model of the steel bridge was developed using Autodesk Revit 2016 .

Table 5. Design conditions

Format	Unit	Simple Plate Girder
Bridge Length	m	40.80
Girder Length	m	40.60
Skew Angle	Degree	0°
Live Load		B Live Load
Large Vehicle Traffic Volume	Number of Vehicles / Day / Direction	2000 or greater
Slab Thickness	mm	250
Design Lateral Seismic Coefficient		Kh = 0.25

Quantity Survey Units and Numerical Digits

- The “Quantity Survey Outlines and Guidelines” defines units and numerical digits to be used for the quantity survey of work items.
- Therefore, when calculating quantities from a 3D product model, the unit and numerical digit of “width”, “height”, “length” and “volume” or “quantity” used for quantification must be adapted.
- However, it must be noted that different calculation results will be yielded, unless cubic volume is calculated with appropriate rounding off (set in accordance with the number of digits defined by the rebar extend curve).

Table 6. Units and numerical digits of quantification (extract)

Bill of Quantities	Classification	Unit	Number	Summary
Steel Material Volume	Width	m	3 Places Below Decimal Place	Round Off to 4 Decimal Places
	Height	m	3 Places Below Decimal Place	Round Off to 4 Decimal Places
	Length	m	3 Places Below Decimal Place	Round Off to 4 Decimal Places
	Capacity	kg	Round Off to Integer	Round Off to 1 Decimal Place

Steel Bridge Upper Deck

- Figure 2 shows the drawing of the steel bridge upper deck .
- When counting work items for the steel bridge upper deck, the number of fabrication materials must be quantified.
- In order to achieve this, the components and calculation method shown in Table 7 are used to generate components of upper / lower flanges of the main girder, web plates and connection materials.

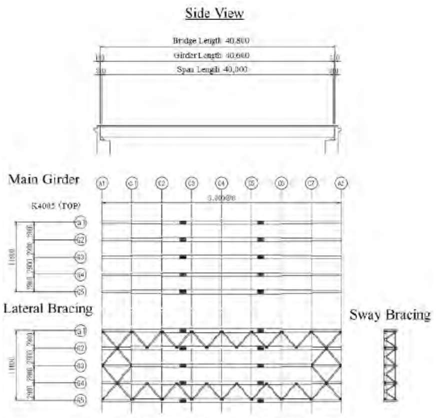


Figure 2. Steel bridge upper deck

Table 7. Structural members and calculation methods

Structural Members	Geometric Representation	Quantity Calculation Unit	Number	Calculation Method	For Quantity Survey Unit
Manufacturing	Solid Model	kg	Round Off to Integer	Section x Unit Volume x Length	t
Bolt/Nut	None (Dummy)	Quantity	Round Off to Integer	Quantity	t

Steel Bridge Upper Deck

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- Figure 3 shows components of the main girder and connection materials.
- Using this information, work items can be quantified at per material-basis.
- In a quantity survey by a government organization, after quantifying of work items, manufacturing costs including assembly time, welding time and temporary assembly time are calculated in addition to material costs, based on the weight of the steel plate per material type.
- When performing this process, assembly time shall be calculated using a block length of component material.

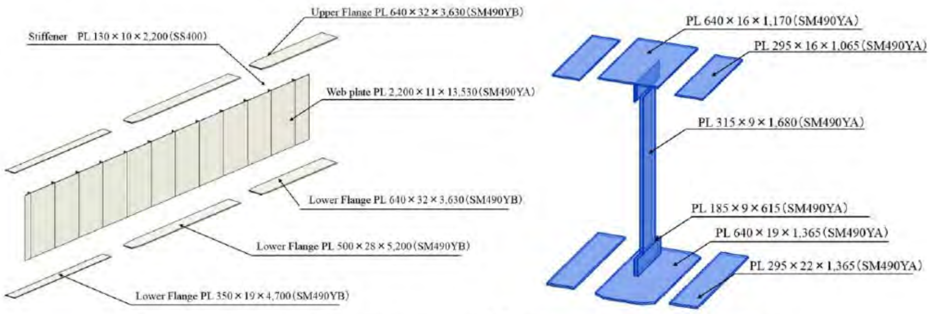

Figure 3. Main girder components and Connection member components

Quantity Survey

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- Figure 4 shows the main girder with all required components in place.
- Using the quantification obtained from the 3D product model, a work quantity summary table (Table 8) was generated and the potential to have the table linked to EVM was investigated.
- Verification was made to ensure work resources, excluding the work hours required for WP of WBS, can be exported to each document format.

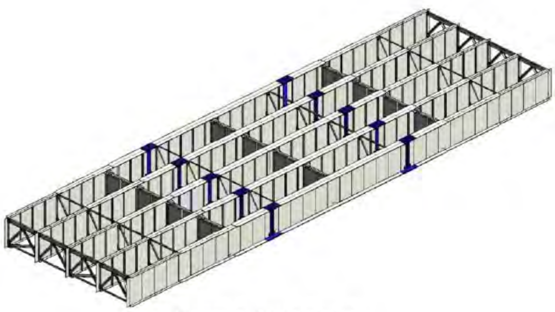


Figure 4. Main girder

Table 8. Work quantity summary table (steel bridge upper deck: girder fabrication) - Main girder

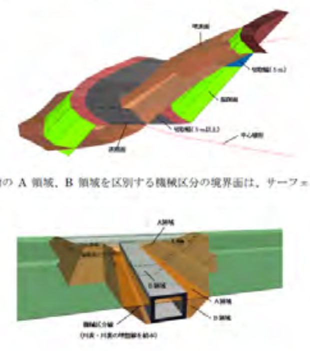
Class-ification	Sectional Dimension	Length (mm)	Quantity	Unit Weight (kgf)	Weight (kgf/Unit)	Weight	Material
Upper Flange							
PL	350 x 19	4,700	2	52.20	245.35	491	SM490YB
PL	500 x 28	5,200	2	109.90	571.48	1,143	SM490YB
PL	640 x 32	3,630	2	160.77	583.59	1,168	SM490YB
PL	640 x 32	12,940	1	160.77	2080.34	2,081	SM490YB
Lower Flange							
PL	350 x 19	4,700	2	52.20	245.35	491	SM490YB
PL	500 x 28	5,200	2	109.90	571.48	1,143	SM490YB
PL	640 x 32	3,630	2	160.77	583.59	1,168	SM490YB
PL	640 x 32	12,940	1	160.77	2080.34	2,081	SM490YB
Wall Panel							
PL	2,200 x 11	13,000	1	189.97	2469.61	2,470	SM490YB
PL	2,200 x 11	13,830	2	189.97	2627.29	5,255	SM490YB

CONCLUSIONS

- In an attempt for government organizations to implement EVM using 3D product modeling, this study evaluated the 3D product modeling of a bridge in order to perform quantity surveying to determine the contract unit of government organizations.
- The Level 4 (Subdivision) unit used for quantity survey of construction work items in Japan is the contract unit for public procurements.
- With further coordination between EVM and quantity survey utilizing 3D product models, project budget-based subdivision of construction sections and project management methods (e.g. work progress management) of government organizations can achieve significant streamlining and improvement.

Result.

The MLIT specifies "Civil Engineering Construction Quantity Survey Outlines and Guidelines (MLIT, FY2018 Edition)".



2) 施工形態（土工モデル）

(A) 掘削

a) 道路

オープンカットや片切掘削等における切取幅（数量算出区分に応じた幅）の境界面は、サーフェスモデル等を用いて表現する。切取幅の境界面サーフェスは、平均断面法と同様に切り出した断面で切取幅の境界線を表現し、一次比例で断面間を補完して接続し、境界面を表現する。

b) 河川

堤防横断構造物の A 領域、B 領域を区別する機械区分の境界面は、サーフェスモデル等を用いて表現する。

(B) 盛土

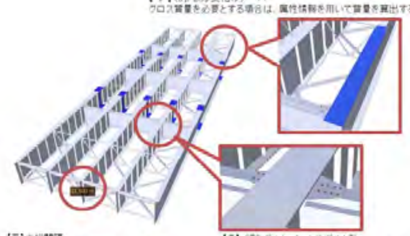
a) 道路

路体盛土の施工幅員（数量算出区分に応じた幅）は、サーフェスモデル等を用いて表現する。施工幅員の境界面のサーフェスモデルは、平均断面法と同様に切り出した断面で切取幅の境界線を表現し、一次比例で断面間を補完して接続し、境界面を表現する。

なお、路床盛土の平均幅員（（上幅＋下幅）× 1/2）は、測点毎に 3 次元モデルより断面を切り出して路床盛土の平均幅員を算出し、その結果を施工形態の属性情報とする。

b) 河川

築堤盛土の施工幅員（数量算出区分に応じた幅）は、サーフェスモデル等を用いて表現する。施工幅員の境界面のサーフェスモデルは、上記の道路盛土と同様に、切り出した断面で切取幅の境界線を表現し、一次比例で断面間を補完して接続し、境界面を表現する。



2.鋼構造物

【3 次元モデルの基本的な表現方法】

Ⅰ：「質量」を算出する項目

・ 3 次元モデルを用いて位置とネット質量を算出し、属性情報を用いて規格や仕様等を区分する。台形部材、全長にわたってテーパーのついた部材等に適用する。

・ グロス質量を必要とする場合は、属性情報を用いて質量を算出する。ガセットプレートや板厚変化のテーパー等に適用する。

Ⅱ：「長さ」、「面積」や「個数」を算出する項目

・ 簡易な形状（点、線、面）を用いて位置、延長や面積を算出し、属性情報を用いて規格や仕様等を区分する。溶接延長、ハンドホール、マンホール、ボルト・ナットやボルト孔等に適用する。

Ⅲ：3 次元モデルに関連付けした属性情報より数量算出条件を抽出する項目

・主桁間隔や高さ等を算出する項目に適用する。

・塗装工等の全表面積等を算出する項目に適用する。

なお、上記は、数量算出における 3 次元モデルの基本的な表現方法を示すものであり、必要に応じて「Ⅱ」や「Ⅲ」に分類されている項目に「Ⅰ」や他の表現方法を用いることを妨げるものではない。

【Ⅰ】(例)板厚変化のテーパー
グロス質量を必要とする場合は、属性情報を用いて質量を算出する。

【Ⅲ】主桁間隔
3次元モデルに関連付けした属性情報より数量算出条件を抽出する項目

【Ⅱ】(例)ボルト・ナットやボルト孔
簡易な形状(点、線、面)を用いて位置、延長や面積を、属性情報を用いて規格や仕様等を区分する

Thank you for your attention.