To be State of Construction

Five Principles of Construction

# Scientific Assessment Model for Construction Solution Selection

International Press-in Association

# INDEX

Under limited natural resource of global environment, it is a serious mission for present and future construction industry i) to develop safe and secure infrastructure against natural disasters without further destroying rich, natural environment while protecting the traditional culture rooted in history and culture and ii) to build recyclable, sustainable society while increasing daily benefit.

In such social conditions, the greater the role of construction is, the greater impact on environment and human society by construction innovation and rationality of the solution selection, needless to say. Thus, it is desired that construction solution needs to be selected not only from owner's, designer's or contractor's point of view but also from general public, taxpayer who is the real owner of the infrastructure. Furthermore, it is desired to select a proposed structure based on its "functional feature" that captures life cycle of the construction project from planning to removal or disposal regardless of traditional definition of the structure.

Figure 1 shows a lifecycle flow of information from planning of infrastructure to removal or disposal of built structure and involvement in decision-making process schematically.

Based on the above background, this paper, proposes an evaluation model with the Five Principles of Construction to contribute to the selection of the best construction solution for general public.

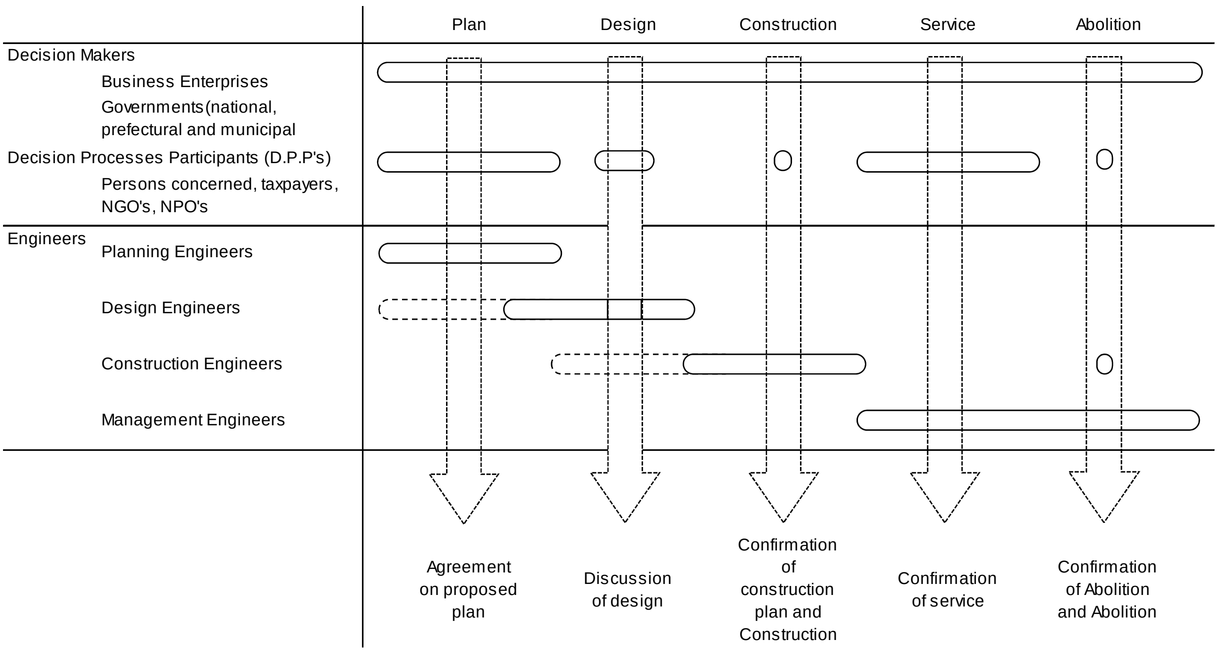


Figure 1: Construction Project Lifecycle and Positioning at Each Phase

Refer from "Guidelines for Design of Environmental-Load Reduction Oriented Structures"

# 1. THE FIVE PRINCIPLES OF CONSTRUCTION

Basic requirements when selecting a construction project or solution (hereinafter referred to as a principle) are defined as such five criteria as Environmental Protection, Safety, Speed, Economy and Aesthetics as explained as follows. Desired construction solution is selected by a well-balanced satisfaction of each of the principles rather than satisfying any of them independently. Therefore, these five items are identified as "The Five Principles of Construction," and an assessment model is proposed in determining the overall balance and level of compliance of each principle.

**■Environmental Protection**

It is important to promote low carbon footprint society, natural environment conservation and sound material recyclable society for pollution prevention in the era of global environmental community or of surrounding area.

**■Safety**

The Safety principle has been identified as an important management item for many years. The Safety principle is one of the most important factors for owners, designers, contractors, and residents, so the selected construction solution itself must conform to this principle.

**■Speed**

It is important that construction work completed as quickly as possible. The Speed is an important principle in terms of the construction cost and safety.

**■Economy**

People who pay tax are source of public works funding. Therefore, The Economy is a key principle for either of owners, designers, contractors or individuals.

**■Aesthetics**

Creating things is assumed to increase cultural value. Therefore, it is important not only to achieve a fully functional built structure but also to assure quality, to utilize such advanced technology as construction rationalization and computer integrated construction and to satisfy such human sensitivity as landscape, functional beauty, symbolic value and artistic value. These factors consist of the principle of the Aesthetics.

# 2. ASSESSMENT CRITERIA, INDICATOR AND WEIGHTING

In this section each of the assessment criteria, indicator and weighting for the five principles is illustrated.

## 2.1 DEFINITION OF CRITERIA AND INDICATOR

Assessment criteria and indicators have been solicited and selected based on various case studies, comparative studies and brain storming through dedicated projects regarding a number of soil engineering and foundation and bridge construction design and management practices of Giken Seisakusho Co., Ltd. In addition, the assessment of the Environmental Protection principle incorporates the research paper, “Guidelines for Design of Environmental-Load Reduction Oriented Structures, 2001” published by Association of Japan Society of Civil Engineers commissioned by the Association of World Exposition in Japan.

## 2.2 ASSESSMENT ITEMS

Each of the assessment criteria of the Five Principles of Construction, Environmental Protection, Safety, Speed, Economy and Aesthetics consists of the three-tiered classification.

### 2.2.1 ENVIRONMENTAL PROTECTION

From the viewpoint of reducing negative environmental impact, the items of Regional Environment and Global Environment are selected as Tier 1, the highest assessment criteria. The item of Landscape and Harmony with surroundings re categorized in the Aesthetics principle.

#### I) REGIONAL ENVIRONMENT

Construction Pollution is identified as Tier 2 assessment criteria. Excessive Noise, Ground Vibration, Air Pollution, and Dust Pollution are identified in the third assessment criteria, Tier 3. In addition to the items above, such item as Stench, Water Pollution, Land subsidence, Soil Pollution, etc. can be added or replaced if it is appropriate to do so depending on the type of construction or construction environment.

#### II) GLOBAL ENVIRONMENT

Under Global Environment criteria in Tier 2, Land Deformation, the cause of destruction of nature and ecosystem, Global Warming Effects, the cause of destruction of natural resource and environment on the earth, and Efficient Use of Resources related to recycling society are identified. In Tier 3, the Contact Area on the Earth during construction stage or of built structure itself is identified under Land Deformation criteria. Greenhouse Gas emission rate such as carbon foot print is identified under Global Warming criteria. Resource Recovery is identified under the Efficient Use of Resource criteria in Tier 2.

In addition to the items listed above, Ozone Depletion, Acid Rain and Resource Consumption are among other items that should be included in Tier 3 under Global Warming Effects. These items should be replaced depending on construction and construction environment. Occupational Health Environment is categorized in the Aesthetics principle.

## 2.2.2 SAFETY

The items of Safety of Built Structure and Safety of Construction Work in Tier 1 are identified in the assessment criteria for the Safety principle.

### I) SAFETY OF BUILT STRUCTURE

Safety in Public Use and Safety against Disaster are identified in Tier 2 under Safety of Built Structure in Tier 1 criteria. In Tier 3 criteria Durability, Load Bearing Capacity, Fire Resistance and Structural Property of Disaster Prevention of Tier 3 items are categorized under Safety in Public Use in Tier 2. Functional Stability against Damage suffered by Disaster of Tier 3 is categorized under Safety against Disaster in Tier 2.

### II) SAFETY OF CONSTRUCTION WORK

Safety on Site and Safety for Neighborhood are categorized in Tier 2. Safety Operation of Machine and Method is categorized under Safety on Site of Tier 2. Possibility of Physical Impact is categorized under Safety for Neighborhood of Tier 2. In addition, there are such items as Property Value that can be replaced or added case by case if appropriate.

## 2.2.3 SPEED

The items of Construction Work Duration and Community Measure Duration are specified as Tier 1 criteria of the Speed principle.

### I) DURATION OF ACTUAL CONSTRUCTION WORK ON SITE

Duration of Actual Construction Work on Site is identified as Tier 2 item.

### II) DURATION OF MEASURES AND NEGOTIATION WITH NEIGHBORS

Duration of Measures and Negotiation with Neighbors before and during construction is identified as Tier 2 item.

In addition, there are such items as Work Conditions, Productivity and Construction Solution Characteristics that should be added or replaced depending on type of construction or construction environment.

## 2.2.4 ECONOMY

Construction Work Cost, Community Measure Cost and Social Cost are identified in this principle as Tier 1 items.

### I) CONSTRUCTION WORK COST

Material Cost, Transportation Cost and Work Execution Coat are categorized as Tier 2 items. Permanent Work Material and Temporary Work Material are identified as Tier 3 items.

### II) COMMUNITY MEASURE COST

Cost of Measures and Negotiations with Neighbors for Environment and Safety is identified as Tier 2 item.

### III) SOCIAL COSTS

Negative Impact during Construction Work is categorized as Tier 2 items and Economic Loss by Functional Interruption is categorized as Tier 3 item.

In addition, there are such items as Maintenance Cost and Environmental Restoration Cost should be added or replaced depending on construction or construction environment.

## 2.2.5 AESTHETICS

Functionality and Quality, Beauty of Built Structure and Rationality of Construction are categorized as Tier 1 items.

### I) FUNCTIONALITY AND QUALITY

Functionality of Structure and Quality Assurance are categorized as Tier 2 items. Under Functionality of Structure, Barrier-free Universal Design, Operability, Drivability, Watertightness and Airtightness are categorized as Tier 3 items. Quality Visualization is categorized as Tier 3 item under Quality Assurance.

### II) BEAUTY OF BUILT STRUCTURE

Compatibility with Surroundings and Symbolism of Structure are categorized as Tier 2 items. Under Compatibility with Surroundings, Harmony with Landscape and Townscape is categorized as Tier 3 item. Under Symbolism of Structure, Tier 3 items of Appealing Shape and Originality and Elements as Landmark are categorized.

### III) RATIONALITY OF CONSTRUCTION

System Integration and Mechanical Automation are categorized as Tier 1 items. Under System Integration, Work Procedure is categorized. Under Mechanical Automation, Human labor is categorized. These items are also related to industrial safety and health.

In addition, there are such items as Comfort, Space-saving Construction, Spiritual value, Consensus Making and Historical Value and so forth should be added or replaced depending on construction situation or environment.

## 2.3 ASSESSMENT INDICATOR

For Assessment Criteria described in Section 2.2, the specific metrics, units for assessment, is introduced. For example, such metrics as the Amount of Noise and Emissions, Construction Costs and Duration that can be expressed quantitatively and such metrics as Safety and Symbolism that should be expressed qualitatively are separately categorized.

In the early stages of construction planning, for assessment criteria or indicators, it is often unclear to specify the number or use of equipment and material for construction. It is important to simplify and thus speed up in assessment indicator selection by utilizing qualitative representation as preliminary assessment.

Figure 2 shows the Five Principles of Construction and its assessment criteria and indicators for each principle summarized in hierarchal manner.

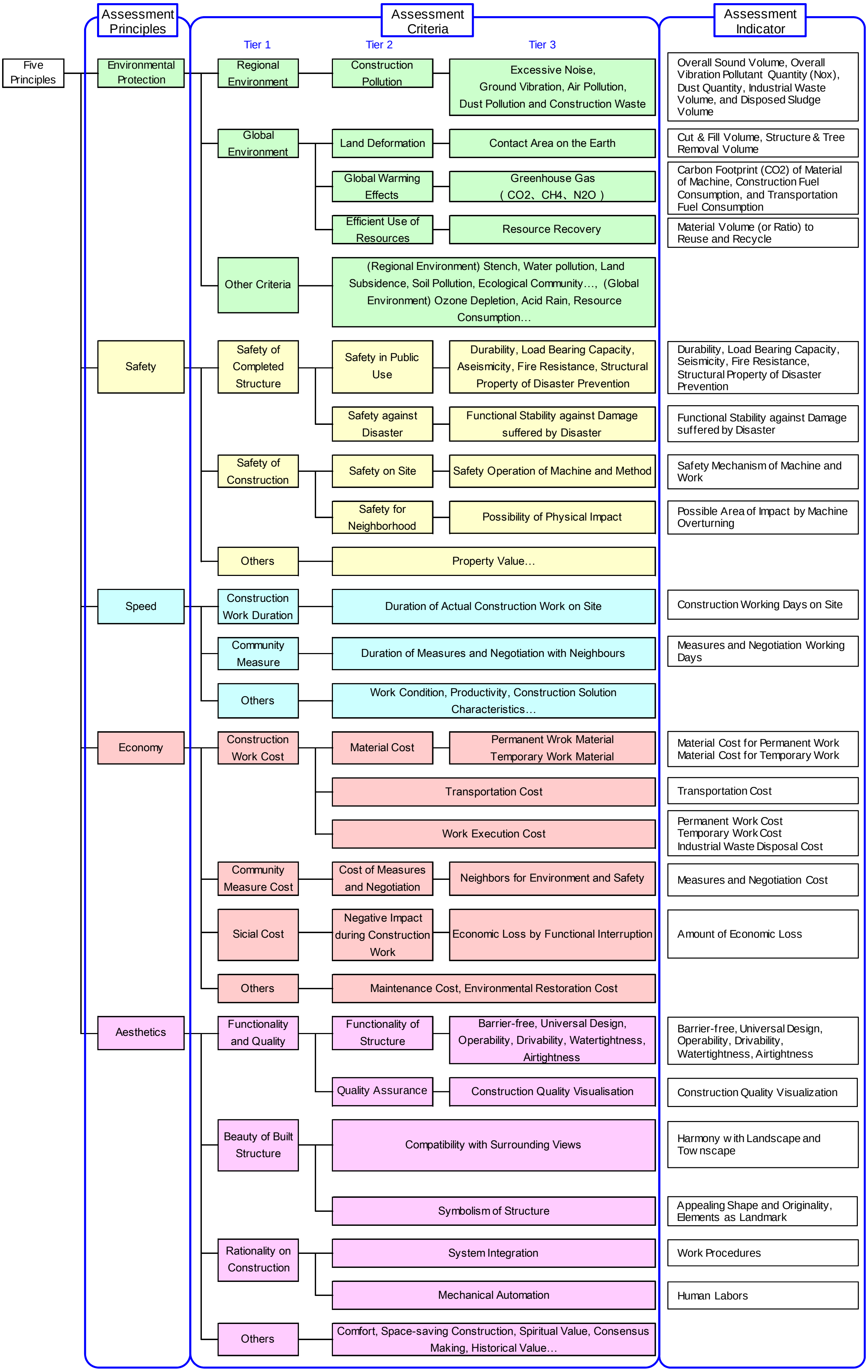


Figure 2: Hierarchical list of the Five Principles of Construction and its assessment criteria and indicators

## 2.4 ASSESSMENT WEIGHT

It is required that assessment criteria and indicators illustrated here be weighted in consideration of present needs, either planning, design or construction stage, situation of location, and neighboring environment conditions instead of considering uniform assessment criteria.

In this assessment model, referring to various experience of real-life design and construction projects and assessments of past case studies, each assessment weighting has carefully been specified. The weight rating with 100% maximum point is distributed to each of the principles and further distributed among assessment weight criteria of Tier 1 and groups of Tier 2 and Tier 3.

The assessment weighting rule is not intended to be unchanged, rather it is intended to be flexibly alternated or updated depending on the type of structure, type of construction scope, type of circumstances and demands of project decision makers and general public.

Table 1 is the Five Principles of Construction Assessment Table, illustrating assessment principles, assessment criteria and assessment indicators as well as assessment weighting at a glance.

## Five Principles Assessment Table

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| Assessment Principle | Assessment Criteria: Tier 1 | Tier 2 | Tier 3 | Assessment Indicator: Indicator Name | Unit | Indicator Metrics | Indicator Point | Assessment Weight: Tier 1 | Tier 2 | Tier 3 | Weighted Indicator Point | Assessment Score (Sum) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Environmental Protection | Regional Environment | Construction Pollution | Excessive Noise, Ground Vibration | Overall Sound Volume | dB(A) | | | 60% | 40% | | 0.00 | 0.00 |
| | | | | Overall Vibration | dB(A) | | | | | | | |
| | | | Air Pollution, Dust Pollution | Pollutant Quantity (Nox), Dust Quantity | Qualitative: Little-5P, Normal-4P, Much-3P | | | | 10% | | 0.00 | |
| | | | Construction Waste | Industrial Waste Volume, Disposed Sludge Volume | $m^3$ | | | | 10% | | 0.00 | |
| | Global Environment | Land Deformation | Contact Area on the Earth | Cut & Fill Volume, Structure & Tree Removal Volume | $m^3$ ($m^2$) | | | 40% | 20% | | 0.00 | |
| | | Global Warming Effects | Greenhouse Gas ($CO_2$、$CH_4$、$N_2O$) | Carbon Footprint ($CO_2$) of Material | t-$CO_2$ | | | | 10% | | 0.00 | |
| | | | | of Machine | t-$CO_2$ | | | | | | | |
| | | | | of Construction Fuel Consumption | t-$CO_2$ | | | | | | | |
| | | | | of Transportation Fuel Consumption | t-$CO_2$ | | | | | | | |
| | | Efficient Use of Resources | Resource Recovery | Material Volume (or Ratio) to Reuse and Recycle | t, % (Good, Satisfied, Bad) | | | | 10% | | 0.00 | |
| | Other Criteria: (Regional Environment) Stench, Water pollution, Land Subsidence, Soil Pollution, Ecological Community…, (Global Environment) Ozone Depletion, Acid Rain, Resource Consumption… | | | | | | | | | | | |
| Safety | Safety of Completed Structure | Safety in Public Use | Durability, Load Bearing Capacity, Seismicity, Fire Resistance, Structural Property of Disaster Prevention | | Qualitative: Good-5P, Satisfied-4P, Bad-3P | | | 60% | 30% | | 0.00 | 0.00 |
| | | Safety against Disaster | Functional Stability against Damage suffered by Disaster | | Qualitative: Good-5P, Satisfied-4P, Bad-3P | | | | 30% | | 0.00 | |
| | Safety of Construction Work | Safety on Site | Safety Operation of Machine and Method | Safety Mechanism of Machine and Work | Qualitative: Good-5P, Satisfied-4P, Bad-3P | | | 40% | 15% | | 0.00 | |
| | | Safety for Neighborhood | Possibility of Physical Impact | Possible Area of Impact by Machine Overturning | $m^2$ | | | | 25% | | 0.00 | |
| | Other Criteria: Property Value… | | | | | | | | | | | |
| Speed | Construction Work Duration | Duration of Actual Construction Work on Site | | Construction Working Days on Site | Day | | | 80% | 80% | | 0.00 | 0.00 |
| | Community Measure Duration | Duration of Measures and Negotiation with Neighbors | | Measures and Negotiation Working Days | Day | | | 20% | 20% | | 0.00 | |
| | Other Criteria: Work Condition, Productivity, Construction Solution Characteristics… | | | | | | | | | | | |
| Economy | Construction Work Cost | Material Cost | Permanent Work Material | Material Cost for Permanent Work | JPY | | | 80% | 80% | | 0.00 | 0.00 |
| | | | Temporary Work Material | Material Cost for Temporary Work | JPY | | | | | | | |
| | | Transportation Cost | | Transportation Cost | JPY | | | | | | | |
| | | Work Execution Cost | | Permanent Work Cost | JPY | | | | | | | |
| | | | | Temporary Work Cost | JPY | | | | | | | |
| | | | | Industrial Waste Disposal Cost | JPY | | | | | | | |
| | Community Measure Cost | Cost of Measures and Negotiation with Neighbors for Environment and Safety | | Measures and Negotiation Cost | JPY (Little, Normal, Much) | | | 10% | 10% | | 0.00 | |
| | Social Cost | Negative Effect during Construction Work | Economic Loss by Functional Interruption | Amount of Economic Loss | JPY (Little, Normal, Much) | | | 10% | 10% | | 0.00 | |
| | Other Criteria: Maintenance Cost, Environmental Restoration Cost | | | | | | | | | | | |
| Aesthetics | Functionality and Quality | Functionality of Structure | Barrier-free, Universal Design, Operability, Drivability, Watertightness, Airtightness | | Qualitative: Good-5P, Satisfied-4P, Bad-3P | | | 40% | 20% | | 0.00 | 0.00 |
| | | Quality Assurance | Construction Quality Visualization | | Qualitative: Good-5P, Satisfied-4P, Bad-3P | | | | 20% | | 0.00 | |
| | Beauty of Built Structure | Compatibility with Surroundings | | Harmony with Landscape and Townscape | Qualitative: Good-5P, Satisfied-4P, Bad-3P | | | 30% | 15% | | 0.00 | |
| | | Symbolism of Structure | | Appealing Shape and Originality, Elements as Landmark | Qualitative: Good-5P, Satisfied-4P, Bad-3P | | | | 15% | | 0.00 | |
| | Rationality on Construction | System Integration | | Work Procedures | Number of Work | | | 30% | 15% | | 0.00 | |
| | | Mechanical Automation | | Human Labors | Number of Worker | | | | 15% | | 0.00 | |
| | Other Criteria: Comfort, Space-saving Construction, Spiritual Value, Consensus Making, Historical Value... | | | | | | | | | | | |

# 3. ASSESSMENT PROCEDURE

Five assessment principles has three stages, or tiers in each principle, consisting of Tier 1, Tier 2 and Tier 3. In addition, both quantitative and qualitative assessment indicators are specified in the lowest tier, Tier 3. In most cases, quantitative assessment indicator should be applied but qualitative one can be applied if appropriate.

It is important to keep well-balanced selection of assessment criteria and indicator comprehensively and reasonably based on the third-party project participants' point of view, such as decision makers of public works or owners, engineers at each stage and more importantly general public who are actual user of the infrastructure as well as tax payer. It tends to be difficult, however, to select quantitative assessment indicator as some of the assessment indicators cannot be well-defined at earlier stages of a project. It is recommended that both qualitative and quantitative assessment indicators be selected with reasonable combination of them if needed.

The weighting of assessment metrics should be carefully determined based on the priority or situation as the relative importance of assessment indicator varies depending on project stages either design stage or construction stage and depending on site condition and surroundings. In this regard, the assessment model introduced here allows dealing with the requirements above.

The total metrics of assessment indicator is set to "5" as maximum value with non-dimensionalization. This modified metrics is called indicator point. It is further calculated by applying assessment weight to each indicator point and called weighted indicator point. Finally the assessment score is calculated with the sum of weighted indicator point for each principle. Then the assessment score for each principle is visualized with a pentagon-shaped radar chart and compered with each other. This visualization enables relative, fair comparison scheme among options of construction methods evaluated.

Figure 3 illustrates overall assessment procedure from selecting assessment criteria to visualization of the result.

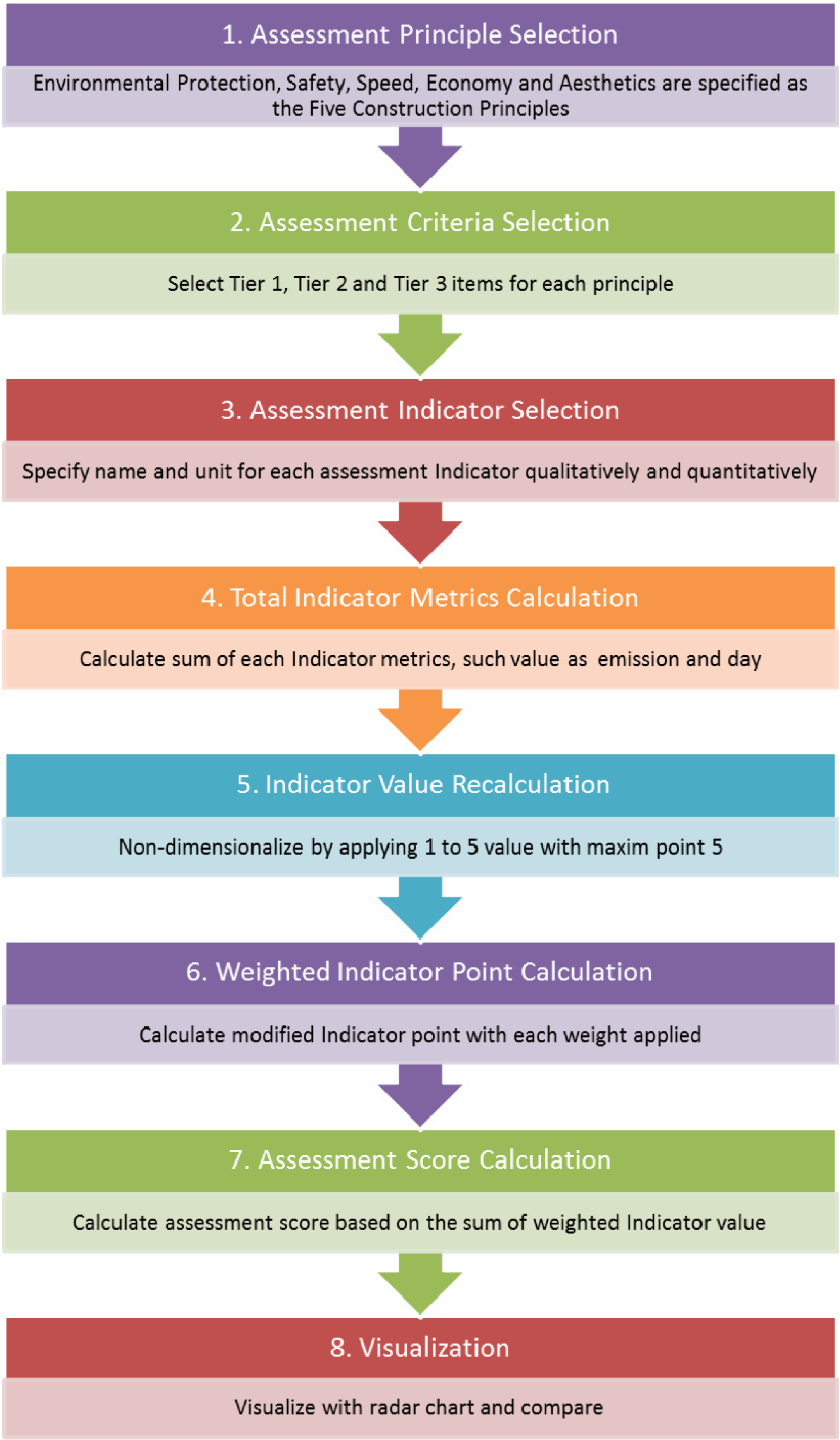


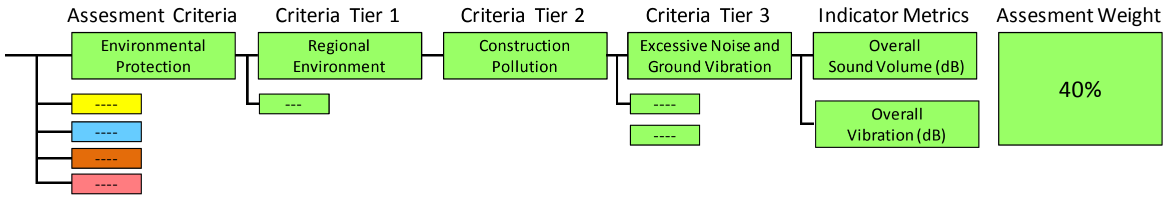

Figure 3: Overall Procedure of Assessment Model

## 4.1 PROCEDURE

Here is an assessment process example. The following chart shows the assessment process starting from assessment criteria and indicator selection, to assessment metrics and point calculation, to weighted indicator point calculation and finally to assessment score calculation. For instance, it starts from specifying Regional Environment in Tier 1, then selects Construction Pollution in Tier 2 and finally selects Air and Dust Pollution in Tier 3.

-Example-

Assessment Process Example with Excessive Noise and Ground Vibration selected




**1st Process: Indicator Metrics Input** Indicator value should be acquired with sum of maximum emission volume and day.

| | Method A | Method B | Method C |
|---|---|---|---|
| Overall Sound Volume (dB) | 375 | 750 | 1,875 |
| Overall Vibration (dB) | 425 | 850 | 2,125 |
| Total | 800 | 1,600 | 4,000 |

* How to calculate indicator value
Overall Sound Volume (dB) = Assumed maximum sound volume multiplied by working days
Overall Vibration (dB) = Assumed maximum vibration multiplied by working days

**2nd Process: Apply Indicator Point** Total indicator metrics should be replaced with indicator point and made it dimensionless.

| | Method A | Method B | Method C |
|---|---|---|---|
| Indicator Metrics | 800 | 1,600 | 4,000 |
| Indicator Point | 5.00 | 2.50 | 1.00 |

* How to apply indicator Metrics
Apply highest value of "5" to the best-scored method among competition
Indicator point of the competition is acquired by the value divided by the best-scored value and multiplied by 5.

**3rd Process: Apply Weight** Weighted indicator point should be acquired with indicator point multiplied by assigned weight.
Weighting can be adjusted depending on the character of the method.

| | Method A | Method B | Method C |
|---|---|---|---|
| Indicator Point | 5.00 | 2.50 | 1.00 |
| Assessment Weight | 40% | 40% | 40% |
| Weighted Indicator Point | 2.00 | 1.00 | 0.40 |

Weighted indicator point is acquired by the indicator point acquired by the second process above multiplied by the weight appropriately adjusted according to the project
*For instance, 40% is Assessment weight of "Excessive Noise and Vibration."

**4th Process: Calculate Weighted Indicator Points of Each Assessment Criteria** Calculate weighted indicator points of every Assessment criteria

| Assessment Principle | Assessment Criteria | | | Assessment Weight | Weighted Indicator Point | | |
|---|---|---|---|---|---|---|---|
| | | | | | Method A | Method B | Method C |
| Environmental Protection | Regional Environment | Construction Pollution | Noise and Ground Vibration | 40% | 2.00 | 1.00 | 0.40 |
| | | | Air Pollution Dust Pollution | 10% | 0.50 | 0.25 | 0.10 |
| | | | Construction Waste | 10% | 0.50 | 0.25 | 0.10 |
| | Global Environment | Land Deformation | Contact Area on the Earth | 20% | 1.00 | 0.50 | 0.20 |
| | | Global Warming Effect | Greenhouse Gas $CO_2$ $CH_4$ $N_2O$ | 10% | 0.50 | 0.50 | 0.50 |
| | | Efficient Use of Resource | Resource Recovery | 10% | 0.50 | 0.25 | 0.10 |
| Total | | | | 100% | 5.00 | 2.75 | 1.40 |

Weighted indicator points are calculated in every assessment criteria of the other assessment principles.

**5th Process: Calculate Assessment Score of Each Principle** Calculate assessment score of each principle

| Assessment Principle | Assessment Score | | |
|---|---|---|---|
| | Method A | Method B | Method C |
| Environmental Protection | 5.00 | 2.75 | 1.40 |
| Safety | 5.00 | 4.00 | 2.00 |
| Speed | 5.00 | 3.00 | 5.00 |
| Economy | 5.00 | 3.50 | 4.00 |
| Aesthetics | 5.00 | 4.00 | 1.00 |
| Total | 25.00 | 17.50 | 13.40 |

Sum up the figure calculated at the previous process and acquire assessment score in each principle.
The higher the total assessment score of each principle is, the better the method

Assessment scores can be visualized with a pentagon-shaped radar chart, comparing prospective construction method with the compered method. There are two options to select or compare methods.

1) Each score on the axis of the pentagon is higher than the other.

2) Each score on the axis of the pentagon is well-balanced.

Figure 4 shows an assessment example of the method comparison with pentagon-shaped radar charts, illustrating the compered method is apparently inferior to the prospective method both in Speed and Environmental Protection principle and slightly inferior in Aesthetics one.

Figure 5 shows another assessment example of the same comparing methods, illustrating the prospective method has the highest score in Speed principle and the second highest in Environmental Protection principle when each score of the competition is set to “3” as a base point.

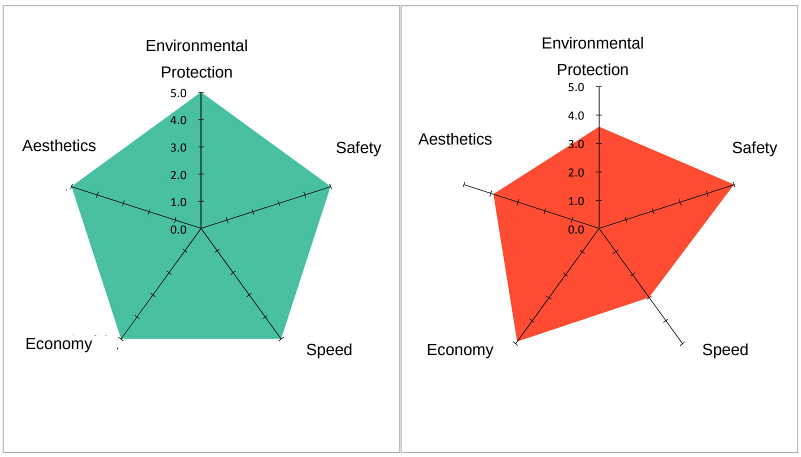



Figure 4: Example of Prospective Method set Score 5 for Each Principle

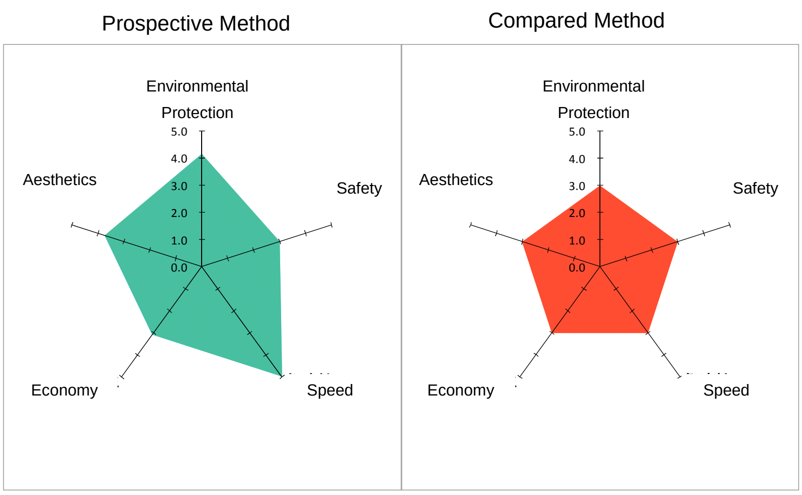



Figure 5: Example of Compared Method set Score 3 for Each Principle

# 5. CONCLUSION

Comprehensive assessment model based on the Five Principles of Construction has been proposed where the best construction method is to selected from general public's point of view. Here is the summary of the advantages of the assessment model. The assessment model:

- provides a comprehensive assessment means by assessing superiority of construction solution or construction method based on the Five Principles of Construction consisting of Environmental Protection, Safety, Speed, Economy and Aesthetics principles;
- provides more reasonable assessment method by assessing each of five principles equally, setting aside regular selection routine weighted only on the factor of economy;
- eradicates one-sided or certain specialty-based assessment or selection process in that each criteria is carefully selected from the view point of owners, engineers and more importantly general public;
- secures fairness as each of the assessment indicators is quantified using publicly available one;
- enables to apply whatever selection process of construction solution or method as all of the assessment indicators and metrics can be replaced according to the difference of construction condition, surroundings or environmental condition;
- puts emphasis on quantification of assessment criteria and indicators, allowing some flexibility in their selection by introducing qualitative assessment instead if quantification is not suitable;
- enables flexible comparison or assessment by allowing replacement of assessment criteria depending on certain phase of a project lifecycle; and
- enables intuitive, comparative, visual assessment process leveraging pentagon-shaped radar chart.

# 6. CHALLENGES

In order to further improve the comprehensiveness and rationality of assessment criteria and indicators, the following action should be taken in the future.

1. Continues to add, replace or update assessment criteria and indicators.

2. Examines validity of assessment weighting process depending on the type of construction solutions and methods.

3. Continues to look over assessment criteria, assessment indicators and assessment weighting by studying many cases of real-life construction projects.

4. Examines validity of non-dimensioning of indicator point and its relativity among each principle.

In order to address the action items above, a variety of case study in construction solution and method comparison needs to be conducted. Assessment criteria and indicators should be polished up through practical case studies.

# FINAL NOTES

In order to further pursue the scientific approach for the assessment model, it may be a good practice to study compatibility with such assessment model as non-monetary assessment or multiple objective decision making model and monetary assessment or cost-benefit analysis. The assessment model is proposed in this document to provide with fundamental assessment means based on the Five Principles of Construction while it is still applicable to apply even in the difficult, constrained business situation.

There seems to be one point of view after another in specifying assessment criteria and indicators depending on the position or situation. Therefore, the assessment model proposed in this document has some flexibility not only in choosing assessment criteria and indicators depending on the situation but also in replacing or even adding or deleting assessment criteria or assessment weight, allowing flexible application depending on the circumstances of environment, situation or industry trend.

Assessment criteria, indicator and procedure of the assessment model should further be evolved by making it available to such stake holder as people with academic background or in public services, designers and practitioners of construction projects, more importantly general public and the other stakeholders who may be concerned and through a number of discussions and advices from them. Positive discussions and comments will be greatly appreciated. Thank you in advance.

References:


1. Design and Build Structures with Reduced Environmental Impact Research Taskforce: “Guidelines for Design of Environmental-Load Reduction Oriented Structures,” ASCE 2001

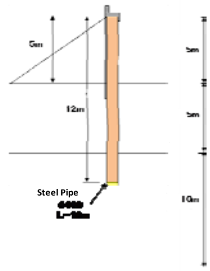
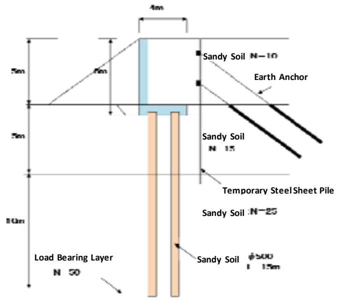
2. Nanase Ogawa, Hiroyuki Yasuoka and Akio Kitamura: “Proposal of Construction Method Assessment Model based on The Five Principles of Construction,” 65th Annual Conference, JSCE 2010

Addendum

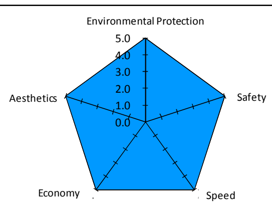
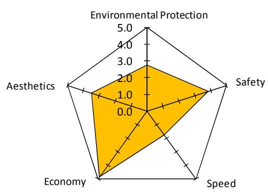
# ASSESSMENT EXAMPLE 1

## Construction Method Assessment of Road Widening Project

Cut off Wall Construction

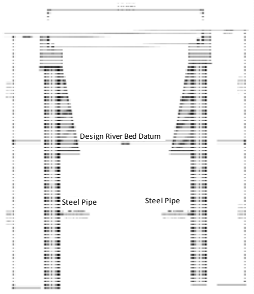
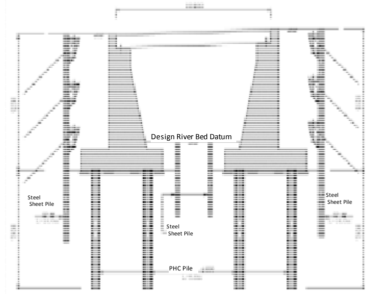
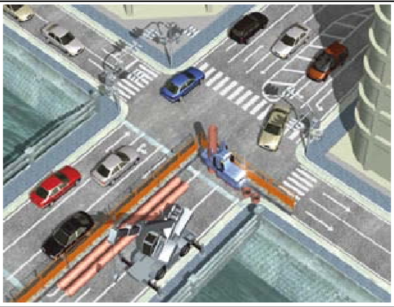
| | Implant Steel Pipe Wall | L-Shaped Retaining Wall |
|---|---|---|
| Cross Section |   |   |
| Construction Site Image |  |  |

| | Principle | Assessment Indicator | Unit | Assessment Weight (%) | Implant Steel Pipe Wall: Assessment Metrics | Weighted Indicator Point | Evaluation Score | L-Shaped Retaining Wall: Assessment Metrics | Weighted Indicator Point | Evaluation Score |
|---|---|---|---|---|---|---|---|---|---|---|
| Assessment Result | Environmental Protection | Excessive Noise, Ground Vibration | db(A) | 40 | 8,800 | 2.0 | 5.0 | 25,120 | 0.7 | 2.8 |
| | | Air Pollution | Qualitative: Good:5, Satisfied: 4, Bad: 3 | 10 | Superior | 0.5 | | Inferior | 0.3 | |
| | | Construction Waste | $m^3$ | 10 | 0 | 0.5 | | 0 | 0.5 | |
| | | Land Deformation | $m^3(m^2)$ | 20 | 188 | 1.0 | | 498 | 0.4 | |
| | | Greenhouse Gas Emission | t | 10 | 428 | 0.5 | | 568 | 0.4 | |
| | | Reuse Recycle | Qualitative: Good:5, Satisfied: 4, Bad: 3 | 10 | Equal | 0.5 | | Equal | 0.5 | |
| | Safety | Safety in Public Use | Qualitative: Good:5, Satisfied: 4, Bad: 3 | 30 | Superior | 1.5 | 5.0 | Superior | 1.5 | 3.9 |
| | | Functional Stability against Damage | Qualitative: Good:5, Satisfied: 4, Bad: 3 | 30 | Superior | 1.5 | | Superior | 1.5 | |
| | | Safety Operation of Machine and Method | Qualitative: Good:5, Satisfied: 4, Bad: 3 | 15 | Superior | 0.8 | | Fair | 0.6 | |
| | | Possibility of Physical Impact | $m^2$ | 25 | 28 | 1.3 | | 1,520 | 0.3 | |
| | Speed | Construction Work Duration | Day | 100 | 55 | 5.0 | 5.0 | 157 | 1.8 | 1.8 |
| | Economy | Construction Work Cost | JPY | 80 | 92,073,750 | 4.0 | 5.0 | 95,552,790 | 3.9 | 4.9 |
| | | Community Measure Cost | Qualitative: Good:5, Satisfied: 4, Bad: 3 | 10 | Equal | 0.5 | | Equal | 0.5 | |
| | | Social Cost | Qualitative: Good:5, Satisfied: 4, Bad: 3 | 10 | Equal | 0.5 | | Equal | 0.5 | |
| | Aesthetics | Functionality od Structure | Qualitative: Good:5, Satisfied: 4, Bad: 3 | 20 | Superior | 1.0 | 5.0 | Superior | 1.0 | 3.5 |
| | | Quality Assurance | Qualitative: Good:5, Satisfied: 4, Bad: 3 | 20 | Superior | 1.0 | | Inferior | 0.6 | |
| | | Compatibility with Surroundings | Qualitative: Good:5, Satisfied: 4, Bad: 3 | 15 | Superior | 0.8 | | Superior | 0.8 | |
| | | Originality, Reliability and Uniqueness | Qualitative: Good:5, Satisfied: 4, Bad: 3 | 15 | Superior | 0.8 | | Superior | 0.8 | |
| | | Task Reduction | # of Task | 15 | 4 | 0.8 | | 27 | 0.2 | |
| | | Mechanical Automation | Man | 15 | 334 | 0.8 | | 1,007 | 0.2 | |
| **Total** | | | | | 25.0 | | | 16.7 | | |

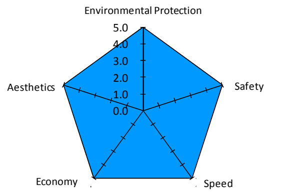
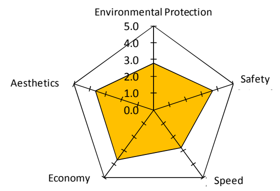
| | Implant Steel Pipe Wall | L-Shaped Retaining Wall |
|---|---|---|
| **Discussion** | -Less environmental impact to neighborhood<br>-Lower risk for machine overturn<br>-Shorter construction duration<br>-Lower cost<br>-Less work breakdown | -More environmental impact to neighborhood<br>-Higher risk for machine overturn<br>-Longer construction duration<br>-Higher cost<br>-More work breakdown |
| **Radar Chart** |   |   |
| **Assessment** | Superior | Inferior |

## Construction Method Assessment of Bridge Replacement Project

Bridge Replacement Project

| | Implant Bridge | Reverse T-shape Abutment Bridge |
|---|---|---|
| **Cross Section** |  |  |
| **Construction Site Image** |  |  |

| | Principle | Assessment Indicator | Unit | Assessment Weight (%) | Implant Bridge: Assessment Metrics | Weighted Indicator Point | Evaluation Score | Reverse T-shape Abutment Bridge: Assessment Metrics | Weighted Indicator Point | Evaluation Score |
|---|---|---|---|---|---|---|---|---|---|---|
| **Assessment Result** | **Environmental Protection** | Excessive Noise, Ground Vibration | db(A) | 40 | 30,400 | 2.0 | 5.0 | 54,400 | 1.1 | 2.8 |
| | | Air Pollution | Qualitative: Good:5, Satisfied: 4, Bad: 3 | 10 | Superior | 0.5 | | Inferior | 0.3 | |
| | | Construction Waste | $m^3$ | 10 | 117 | 0.5 | | 185 | 0.3 | |
| | | Land Deformation | $m^3(m^2)$ | 20 | 122 | 1.0 | | 2,641 | 0.2 | |
| | | Greenhouse Gas Emission | t | 10 | 316 | 0.5 | | 461 | 0.3 | |
| | | Reuse Recycle | Qualitative: Good:5, Satisfied: 4, Bad: 3 | 10 | Equal | 0.5 | | Equal | 0.5 | |
| | **Safety** | Safety in Public Use | Qualitative: Good:5, Satisfied: 4, Bad: 3 | 30 | Superior | 1.5 | 5.0 | Superior | 1.5 | 3.7 |
| | | Functional Stability against Damage | Qualitative: Good:5, Satisfied: 4, Bad: 3 | 30 | Superior | 1.5 | | Superior | 1.5 | |
| | | Safety Operation of Machine and Method | Qualitative: Good:5, Satisfied: 4, Bad: 3 | 15 | Superior | 0.8 | | Inferior | 0.5 | |
| | | Possibility of Physical Impact | $m^2$ | 25 | 52 | 1.3 | | 1,611 | 0.3 | |
| | **Speed** | Construction Work Duration | Day | 100 | 190 | 5.0 | 5.0 | 340 | 2.8 | 2.8 |
| | **Economy** | Construction Work Cost | JPY | 80 | 67,859,000 | 4.0 | 5.0 | 93,623,000 | 2.9 | 3.7 |
| | | Community Measure Cost | Qualitative: Good:5, Satisfied: 4, Bad: 3 | 10 | Equal | 0.5 | | Equal | 0.5 | |
| | | Social Cost | Qualitative: Good:5, Satisfied: 4, Bad: 3 | 10 | Less | 0.5 | | More | 0.3 | |
| | **Aesthetics** | Functionality od Structure | Qualitative: Good:5, Satisfied: 4, Bad: 3 | 20 | Superior | 1.0 | 5.0 | Superior | 1.0 | 3.6 |
| | | Quality Assurance | Qualitative: Good:5, Satisfied: 4, Bad: 3 | 20 | Superior | 1.0 | | Inferior | 0.6 | |
| | | Compatibility with Surroundings | Qualitative: Good:5, Satisfied: 4, Bad: 3 | 15 | Superior | 0.8 | | Superior | 0.8 | |
| | | Originality, Reliability and Uniqueness | Qualitative: Good:5, Satisfied: 4, Bad: 3 | 15 | Superior | 0.8 | | Superior | 0.8 | |
| | | Task Reduction | # of Task | 15 | 7 | 0.8 | | 18 | 0.3 | |
| | | Mechanical Automation | Man | 15 | 494 | 0.8 | | 1,465 | 0.3 | |

| | Implant Bridge | Reverse T-shape Abutment Bridge |
|---|---|---|
| Total | 25.0 | 16.6 |
| Discussion | -Better constructability thanks to simple work sequence and breakdown<br>-Constructible within minimum site space<br>-Less work breakdown thanks to non-staging method without built levee removal<br>-Less negative environmental impact thanks to less construction waste and dirt | -Worse constructability due to complicated work sequence and many work breakdown<br>-Occupy large area for construction<br>-Need to work during less rainy season due to many work within the stream<br>-More negative environmental impact due to many work breakdown such as temporary work, Earth work, Foundation work and Concrete work |
| Radar Chart |  |  |
| **Assessment** | Superior | Inferior |

Your comment or discussion will be greatly appreciated.



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