Low-Carbon and Sustainable Urban Bike Lane Labelling System - A Case Study of Taichung

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Abstract. According to the 2001 assessment report of the intergovernmental panel on climate change (IPCC) of the United Nations, in the past 50 years, climate warming, excessive human development caused environmental impact, global energy shortage and high oil price environment, began to promote green transport, among which the bike advocates environment-friendly and low-pollution transport mode. Under this trend, bike lanes are increasing in Taiwan. Signage systems should be improved to achieve road network safety, continuity, integration and ride friendliness. Traffic labelling system in cities is an integral part of infrastructure construction and urban aesthetics. Kevin Lynch mentioned in The Image of The City that people in modern cities rely on indicator devices, and a good labelling system can help users to identify the environment conveniently and quickly. This study attempts to establish the Taichung city bike lane labelling system design, in order to collect relevant literature review summarized evaluation index, the study points out that network build bike lanes marked by subject system to meet the "Modelling Style", "Chromatic Scheme" and "Material Selection" three as the main index, by the fuzzy Delphi method, collecting group expert advice, in accordance with the subsequent bike lane labelling system design and update.

1. Introduction
Taichung city government, the research development and evaluation commission report 108 pointed out that at present, Taichung city, set up bike lanes in article 90 of the total route length 690.66 kilometres, traffic is very convenient in Taichung, vertical transportation can be combined with high iron, iron line, circle line 1, mountain bike lanes connects the north and south, bike lanes route. However, due to the different design, rights and responsibilities and management units of the current bike lane labelling system, and the different facilities in different years, it is not easy to create a chaotic style without integrity and maintenance management. In the current environment, there are many different traffic signs, which are easy to cause the bike riders cannot quickly identify. This study to construct clear bike lane labelling system, bike road network according to the geographical environment quality planning five topics respectively: all lines to the Metropolis Human line, Ocean line, River line, Boulevard line and Mountain line, because there are five main themes network build, make integral identification, character, labelling system consistency, continuity and self-evident relative increase, reduce the current caused by mixed route labelling system set up too much waste, to achieve the reduction promote low carbon energy saving. The purpose of this study is to design a series of Taichung bike lane labelling system for the purpose of providing design optimization and construction in the future. The purpose of this study is as follows:
1. Application of Fuzzy Delphi method, discuss whether the design of five major theme road network labelling system in Taichung has reached the consensus of group experts?
2. To explore whether the design of the five themes road network bike lane labelling system can reduce the amount of labelling and promote environmental sustainability?
3. According to the research results, the author will respond to the improvement design of Taichung bike lane labelling system, and hope that the government can build or improve bike lane in the future.

2. Literature review

2.1. Environmental graphics
Environmental visual design is the planning, design and interpretation of all the image elements between human and natural environment. The visual communication of these Three-Dimensional Spaces includes signs, road sign system, display design, public art and enterprise identification. Environmental visual design not only provides the integration of various parts in urban space or public space, but also combines clear environmental images in vision and language, as well as other elements of creative environment, to move the public and help the public understand the environment [1]. In terms of the current bike lane labelling system, the signage, warning board and mileage board are all greater than the current needs, resulting in more confusion of environmental vision.

2.2. Type of bike path labelling system
Bike lanes facilities labelling system in style is divided into vertical bar system and the level ground system, the vertical bar system contains direction/fixed signs, mileage card warning signs and commentary tour card, the system of the warning signs and mileage card type and location of the point must abide by the road traffic laws regulations shall not transfer, therefore two signs to be outside the scope of the study. The horizontal ground system contains signs and marks. The type and location of the horizontal ground system must comply with the laws and regulations related to road traffic. Therefore, it is not included in this study. Therefore, this study is based on the direction/point indicator and interpretation guide plate.

| Type            | Style                  | Range of study                                      | Style                  | Range of study                                      |
|-----------------|------------------------|-----------------------------------------------------|------------------------|-----------------------------------------------------|
| Vertical bar    | Direction sign         | Direction signs are divided into plates and rods. This study discusses the presentation mode of plates. | Explanation guide board| This study explores the presentation mode of the guide card. |

2.3. Design index and impact collection
Study to "public signs are commonly used code design reference guide (2005) "]2,]" function and design principle of labelling system (2006) "]3," the environment of bike lanes visual identity design research (2009) "]4]" bike lanes system planning and design reference manual (2017) "]5]" to carry on the literature review, collect related evaluation index, inductive research is pointed out that" Modelling Style ", " Chromatic Scheme ", "Material Selection " and "Set Location" four is the evaluation of the main indicators, "Modelling Style" of the important considerations include unity, simple, legibility and harmony of the four factors, " Chromatic Scheme " considerations include self-evident, identification and environmental harmony three factors of "Material Selection" considerations include durability and environmental harmony factor, and the "Set Location" for 2017 bike trails system planning and design in the reference manual for relevant law regulations, therefore to be outside the scope of the study.
Table 2. Bike lane labelling system Impact Factor interpretation

| Design Index | Impact Factor | Impact Factor interpretation |
|--------------|---------------|-----------------------------|
| 1. Modelling Style | Standardization | There should be consistent expression, using simple international visual images to convey information. |
| | Simplicity | It should strive for simplicity, in order to instantly see clearly. |
| | Clear Communication | It should be easy for users to understand, so as to achieve visibility and readability. |
| | Compatibility | All patterns have the same structure to achieve visual harmony. |
| 2. Chromatic Scheme | Identity | Be able to clearly perceive the relationship between the elements and the local characteristics, and the connection with the environment. |
| | Identifiability | Colour brings out visual information that can be detected and distinguished. |
| | Environmental Compatibility | The bike path labelling system is in harmony with the surroundings. |
| 3. Material Selection | Persistence | How durable the material is for the bike labelling system? |
| | Environmental Compatibility | The bike path labelling system is in harmony with the surroundings. |

3. Research Methods

3.1. Create bike identification system elements

In order to construct a clear bike lane labelling system in Taichung city, the theme road network planned five major themes according to the characteristics of geographical environment: Metropolis Human line, Ocean line, River line, Boulevard line and Mountain line. "Modelling Style" was divided into theme Logo and abstract line. " Chromatic Scheme " based on the basic colours according to Taichung city and bike related LOGO selected five main colours, and then to establish five road network colour theme primary and secondary colour tickets, the main colours accounted for 70%; Auxiliary colour system accounted for 30% of the configuration, reached a consensus with experts meeting, for the follow-up labelling system to achieve consistency, harmony and self - evident.

3.1.1. Metropolis human line. With rich urban cultural customs, the colour of the environment chooses the famous building in the city centre, namely the pavilion in the middle of the lake, the The Luce Chapel and the opera house. The symbol is represented by the image of the pavilion in the middle of lake Taichung. Abstract lines represent buildings in the city, and they can be described as they ride through the buildings. Take the Luce Chapel and Taichung opera house as examples.

Table 3. Metropolis Human line labelling system

| Objective | Environmental color |
|-----------|---------------------|
| Metropolis Human | ![Color sample](image1.png) ![Logo](image2.png) ![Abstract lines](image3.png) |

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3.1.2. **Ocean line.** With the Marine culture and natural style of the west coast, the colour of the environment is blue from ocean waves and dolphins. The symbol is represented by the white dolphin; Abstract lines draw lines with waves and dolphins, representing the image of the ocean.

| Objective | Environmental color |
|-----------|---------------------|
| Ocean     | ![Color sample](image1) ![Logo](image2) ![Abstract lines](image3) |

3.1.3. **River line.** Experience the different characteristics of the waterfront scenery, environment colour selection to Taichung Yanagawa waterway, LuChuan canal, raft creek capture blue and green; The symbol is represented by rivers; Abstract lines to outline Taichung river streamlines and shore willow as the image.

| Objective | Environmental color |
|-----------|---------------------|
| River     | ![Color sample](image1) ![Logo](image2) ![Abstract lines](image3) |

3.1.4. **Boulevard line.** The green corridor is formed by the green forest with beautiful environment, and the environmental colour is selected by green shade, pine tree and so on to capture the bright green system. The symbol and abstract lines are represented by five-leaf pine of Taichung city.

| Objective | Environmental color |
|-----------|---------------------|
| Boulevard | ![Color sample](image1) ![Logo](image2) ![Abstract lines](image3) |

3.1.5. **Mountain line.** The routes are mainly distributed among mountains and fields, and the environmental colour are selected from forest, trees, leaves, etc. Dark green is selected. The symbol is represented by Taichung bird thrush, which often appears in mountainous areas. Abstract lines take mountain edges and purple butterflies as images.
Table 7. Mountain line labelling system

| Mountain | Color sample | Logo | Abstract lines |
|----------|--------------|------|----------------|
|          |              |      |                |

3.2. Fuzzy Delphi method

In qualitative research, this study used the Fuzzy Delphi method of statistics, the Fuzzy Delphi method is by Murray, Pipino & Van Gigch (1985) first combined with fuzzy theory and the improved Delphi method, and the main purpose is to obtain the consensus of experts, on the basis of expert judgment by the development of a method of visual preset and compiled to calculate the comprehensive values and opinions. Through the expert panel and not meet to discuss the principle, can reduce the influence of groups and a few voiceless, and through the feedback mechanism, can effectively further consensus expert group, and can be borrowed by the double triangular fuzzy number to integrate expert cognition, grey area verification to check whether expert cognition has amounted to convergence. The fuzzy Delphi method can be used to calculate the consensus value of experts for the arguments with uncertainty, high degree of rendibility, or more controversial arguments. Therefore, this study conducted an expert questionnaire survey with six respondents, whose professional projects covered urban design, engineering, architecture, landscape and visual communication. At present, they are all engaged in planning and construction of bike lanes.

Questionnaire evaluation method using Likert 10 scale score, the higher the score from 0 to 10 on behalf of the impact factor is more important, according to experts to evaluate personal professional experience, in view of the five major themes in road labelling system "modelling style", "Chromatic Scheme" and "material selection evaluation, according to the double triangular fuzzy number and the verification method of the grey area, using Microsoft Excel 2010 software to collect statistical data, calculate the expert consensus Gi value of importance, as set a threshold value factor, the arithmetic mean of the Gi value, the indicators below the threshold value factor is not up to standard.

4. Results and Discussion

4.1. Metropolis Human line

In the Metropolis Human line labelling system of the five major road network cities, the "Modelling Style" factor and "Chromatic Scheme" factor are all higher than the arithmetic mean Gi value of group experts 6.93, indicating that group experts have reached a consensus on the human line labelling system of the city. In the "Material Selection" factor, "3-1 durability" metal and stone have reached the average consensus value, among which metal ranks first. "3-2 environmental harmony" metal also reached the average consensus value, indicating that the group experts reached a consensus on the metal material selection of the urban human line, and the metal material selection of the Metropolis Human line should be better under the environmental restrictions and maintenance management.

Table 8. Metropolis Human line

| Objective         | Design Index | Impact Factor | Expert Consensus Value (Gi) | The threshold value ($s$) |
|-------------------|--------------|---------------|-----------------------------|--------------------------|
| Metropolis Human  | Modelling    | 1-1 Unity     | 7.56                        | ✓                        |
|                   | Style        | 1-2 Simple    | 6.93                        | ✓                        |
|                   |              | 1-3 Legibility| 7.72                        | ✓                        |
4.2. Ocean line

In five main themes network Ocean line by line labelling system, the wind "Modelling Style" factor in "1-2 simple" Gi value of 7.11 of Gi value arithmetic mean of 7.12, the other factor is higher than the average consensus of value, "Chromatic Scheme" factor is higher than the average consensus of value group experts, the pursuit of the wind out of group experts on sea line labelling system most factors have reached a consensus. In the "Material Selection" factor, "3-1 durability" metal has reached the average consensus value, "3-2 environmental harmony" metal and stone have reached the average consensus value, among which the metal ranking is the first, which indicates that the group experts reach the consensus on the material selection of sea line wind-driven line with metal, and Ocean line should be easy to be eroded by the sea breeze and the environment is windy, and the material selection of maintenance management should be metal.

Table 9. Ocean line

| Objective | Design Index | Impact Factor | Expert Consensus Value (Gi) | The threshold value(s) |
|-----------|--------------|---------------|-----------------------------|------------------------|
| Modelling Style | 1-1 Unity | 7.78 | ✓ |
| | 1-2 Simple | 7.11 | |
| | 1-3 Legibility | 7.60 | ✓ |
| | 1-4 Harmony | 7.86 | ✓ |
| Chromatic Scheme | 2-1 Self-explanatory | 7.93 | ✓ |
| | 2-2 Identification | 7.79 | ✓ |
| | 2-3 Environmental harmony | 7.62 | ✓ |
| Material Selection | 3-1 persistence | metal | 7.73 | ✓ |
| | | wood | 5.20 | |
| | | plastic | 6.25 | |
| | | stone | 6.37 | |
| | 3-2 Environmental harmony | metal | 7.58 | ✓ |
| | | wood | 6.80 | |
| | | plastic | 6.05 | |
| | | stone | 7.20 | ✓ |
| | Arithmetic mean | 7.12 | |

4.3. River line

In five theme leisure network River line labelling system, the "Modelling Style" factor in "1-2 simple" Gi value of 6.73 of Gi value arithmetic mean of 6.90, the other factor is higher than the average
consensus of value, "Chromatic Scheme" factor is higher than the average consensus of value, group experts on riverbank leisure group experts from line labelling system most factors have reached a consensus. In the "Material Selection" factor, "3-1 durability" metal and wood both reach the average consensus value, among which metal ranks first. "3-2 environmental harmony" both metal and wood have reached the average consensus value, among which metal ranks first, indicating that the group experts have reached consensus on the material selection of riverbank recreational line with metal, and the material selection of River line should be better with metal under environmental restrictions and maintenance management.

### Table 10. River line

| Objective | Design Index | Impact Factor | Expert Consensus Value (Gi) | The threshold value(s) |
|-----------|-------------|---------------|-----------------------------|-----------------------|
| Modelling Style | 1-1 Unity | 7.36 | ✓ |
| Chromatic Scheme | 1-2 Simple | 6.73 | |
| | 1-3 Legibility | 7.31 | ✓ |
| | 1-4 Harmony | 7.56 | ✓ |
| | 2-1 Self-explanatory | 7.31 | ✓ |
| | 2-2 Identification | 6.95 | ✓ |
| | 2-3 Environmental harmony | 7.21 | ✓ |
| Material Selection | 3-1 persistence | metal | 7.36 | ✓ |
| | | wood | 7.04 | ✓ |
| | | plastic | 6.46 | |
| | | stone | 6.16 | |
| | 3-2 Environmental harmony | metal | 7.14 | ✓ |
| | | wood | 7.05 | ✓ |
| | | plastic | 5.31 | ✓ |
| | | stone | 6.60 | |
| Arithmetic mean | 6.90 | |

4.4. Boulevard line

In five main themes network Boulevard labelling system, the "Modelling Style" factor in "1-2 simple" Gi value of 7.10 and "1-3 legibility" Gi value of 7.13 of Gi value arithmetic mean of 7.15, the other factor is higher than the average consensus of value, "Chromatic Scheme" factor is higher than the average consensus of value, group experts on shade group experts from cruise line labelling system most factors have reached a consensus. In the "Material Selection" factor of "3-1 durability" wood has reached the average consensus value; "3-2 environmental harmony" wood has reached the average consensus value, which indicates that the group experts reach a consensus on the wood material selection of Green shade line, and the wood material selection of Boulevard line should be better under the harmonious environment.

### Table 11. Boulevard line

| Objective | Design Index | Impact Factor | Expert Consensus Value (Gi) | The threshold value (s) |
|-----------|-------------|---------------|-----------------------------|-----------------------|
| Modelling Style | 1-1 Unity | 7.30 | ✓ |
| | 1-2 Simple | 7.10 | |
| | 1-3 Legibility | 7.13 | |
| | 1-4 Harmony | 7.82 | ✓ |
| Chromatic Scheme | 2-1 Self-explanatory | 7.82 | ✓ |
| | 2-2 Identification | 7.63 | ✓ |
| | 2-3 Environmental harmony | 7.73 | ✓ |
### Material Selection

| 3-1 persistence | Metal | 6.95 |
|-----------------|-------|------|
|                 | Wood  | 7.90 | ✓    |
|                 | Plastic | 6.01 |      |
|                 | Stone  | 6.81 |      |

| 3-2 Environmental harmony | Metal | 6.73 |
|---------------------------|-------|------|
|                           | Wood  | 7.91 | ✓    |
|                           | Plastic | 5.95 |      |
|                           | Stone  | 6.48 |      |

**Arithmetic mean** 7.15

### 4.5. Mountain line

In five main themes network Mountain line labelling system, the "Modelling Style" factor in "1-2 simple" Gi value of 7.06 of Gi value arithmetic mean of 7.23, the other factor is higher than the average consensus of value, "Chromatic Scheme" factor in "2-3 environmental harmony" Gi value of 7.04 is not up to the arithmetic mean of value, the other factor is higher than the average consensus of value, wizard on hydrophilic group experts from mountain line labelling system most factors have reached a consensus. In the "Material Selection" factor, "3-1 durability" wood and stone have reached the average consensus value, among which wood ranks first. "3-2 environmental harmony" wood has reached the average consensus value, which indicates that the group experts reach a consensus on the material selection of mountain-friendly green line with wood, and the material selection of Mountain line should be better with wood under the harmonious environment.

#### Table 12. Mountain line

| Objective | Design Index | Impact Factor | Expert Consensus Value (Gi) | The threshold value (s) 7.23 |
|-----------|--------------|---------------|-----------------------------|-----------------------------|
| Modelling Style | 1-1 Unity | 7.81 | ✓ |
|              | 1-2 Simple | 7.06 | ✓ |
|              | 1-3 Legibility | 7.39 | ✓ |
|              | 1-4 Harmony | 7.40 | ✓ |
| Chromatic Scheme | 2-1 Self-explanatory | 7.68 | ✓ |
|              | 2-2 Identification | 7.94 | ✓ |
|              | 2-3 Environmental harmony | 7.04 | ✓ |
| Mountain | Material Selection | 3-1 persistence | Metal | 7.19 |
| | | | Wood | 7.50 | ✓ |
| | | | Plastic | 6.09 | |
| | | | Stone | 7.40 | |
| | | 3-2 Environmental harmony | Metal | 6.59 |
| | | | Wood | 7.99 | ✓ |
| | | | Plastic | 6.31 | |
| | | | Stone | 7.13 | |
| | | **Arithmetic mean** | 7.23 | |

### 5. Conclusion

Establishing perfect bike lane labelling system to achieve network safety, continuity, integrated and riding friendliness, through this research shows that group of experts for the five topics road bike labelling system " Modelling style " and " Chromatic Scheme " labelling system is to group the expert consensus, and the material selection is Metropolis Human line, Ocean line, River line to metal group expert consensus; Boulevard and Mountain field to achieve group expert consensus with wood. Therefore, the consistency of the signage system can be improved so as to reduce the environmental confusion caused by too many signage in the current situation. In the future, the design and updating
of the signage system for bike lanes in Taichung can be used as a reference to achieve the effect of reducing the quantity and environmental sustainability, so as to improve the urban green traffic network.

6. References

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