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VISUAL CHARACTER OF BOARD-FORMED ENVIRONMENT CONSIOUS MATERIALS

Nozomu Utsugi**, Sun Yiyin**, Mari Abe*, Terumi Shiraishi*

**Graduate School of Engineering, Takushoku University, Tokyo

z6m403, z7m403@id.takushoku-u.ac.jp

*Department of Industrial Design, Faculty of Engineering, Takushoku University, Tokyo

m-abe, tshiraishi@id.takushoku-u.ac.jp

ABSTRACT:

In this research, the environment conscious materials by board-formed natural materials, and their visual characters were clarified. The visual character types were sense of sight, touch by hand and touch by foot, material color, and surface form. From the sensory evaluation, it turned out that sense of sight and touch by hand had the same factors but the sense of touch by foot had different factors from these. As for the material color, the materials which had similar hue and brightness were allocated in the approximately similar positions of the configuration map, the surface form of the materials were observed, and allocated in the configuration map between the

factors. As a result, materials of high density and uniform material color by appearance were considered good in quality for, and materials of low density and in which the directions and color of the elements constituting the material were not uniform were lacking in quality factor.

THE KEYWORDS : Visual Character , Environment Consious Materials,

Sensory Evaluation

1. INTRODUCTION

With regard to materials used in products and equipment such as furniture and fittings, etc. in interior space, those having few influences on the environment or the human body are preferable in order to address environmental problems or the sick building syndrome. Among these materials, there are "environment conscious materials," which include materials designed to take into consideration resource protection, environmental preservation, recycling efficiency, and energy-saving, etc. in each stage of their production, use, and disposal. Among the environment conscious materials, there are materials that have been newly developed, as well as those made through property modification and improvement on the existing materials. For example, in wood composite, adhesives containing less formaldehyde diffusion have begun to be used. Moreover, plywood and particle-board have been produced from domestic softwood materials, such as cedar and cypress which are currently pressed for effective utilization in our country as alternative materials to hardwoods which have been decreasing globally. As for newly developed materials, those made from plants, such as grasses and seeds, and soil materials which were difficult to be treated as industrial materials until now have been utilized, and materials with textures that are different from existing materials have begun to appear. However, it is often seen among the environment conscious materials, those in which the development precedes and each character is not clarified or the materials in which the usage is not stabilized. It is considered that in order to utilize various environment conscious materials effectively, the sensory characteristics, the mechanical characteristics, the physical characteristics, and the characteristics of these materials during processing should be clarified, and it is urgently necessary to create a database for interior materials selection in the design phase.

In this research, board-making materials, made mainly from natural materials were identified among environment conscious materials, and the visual characters of these materials were clarified as a way to facilitate interior materials selection.

2. SENSORY EVALUATION

2.1 EXPERIMENT METHOD

In order to clarify sensory characteristics of environment conscious materials, sensory experiments were performed. The experiments were performed through the sense of visual appearance only, the sense of touch by hand including the sense by vision, and the sense of touch by foot including visual appearance, based on the SD method. 16 paits of SD evaluation words were used in the experiment. They were selected and determined through questionnaires completed by interior and furniture design specialists. The evaluation had seven steps. The assessment sheet used is shown in Fig. 1. The examinees were students of Takushoku University, 28 male and 14 female, 42 in total. The environment conscious materials used for the experiment were 2 types of raw materials and 17 types of processed materials, 19 types in total, and the types are shown in Fig. 2. The 2 types of raw materials were cedar and beech, 2 different. The 17 types of processed materials were 9 types of wood materials (lauan plywood, domestic thinning wood board, MDF, LVL, PSL, OSB, cork board, carbonization cork board, and compressed wood), 3 types of grass materials (laminated wood of bamboo, bioboard, and rush board), 2 types of soil materials (expanded vermiculite board and diatomite diatomaceous earth board), 1 type of seed material (dakotaburl), 1 type of animal fiber material (compressed felt), and 1 type of seed and paper material (environ). The surface form of each of these materials is shown in Fig. 3. The materials used in the evaluation were 120 mm square pieces. The experiment was performed firstly through the sense by vision only, secondly through the sense of touch by hand including the sense of vision, then thirdly through the sense of touch by foot including the sense of vision. The experimental conditions are shown in Fig. 4 and Fig. 5. Fig. 4 shows the sensory experiment through the sense of vision only, and Fig. 5 shows the sensory experiment through the sense of foot touch.

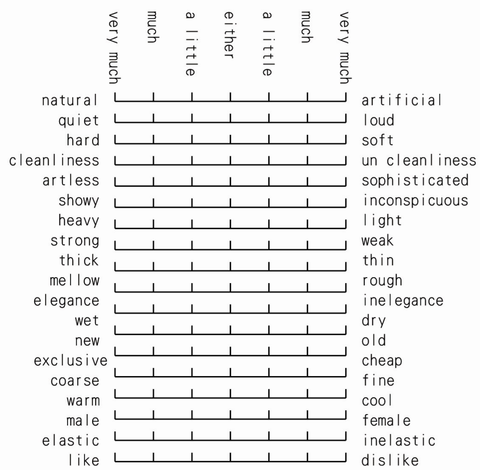


Fig.1 Evaluation sheet

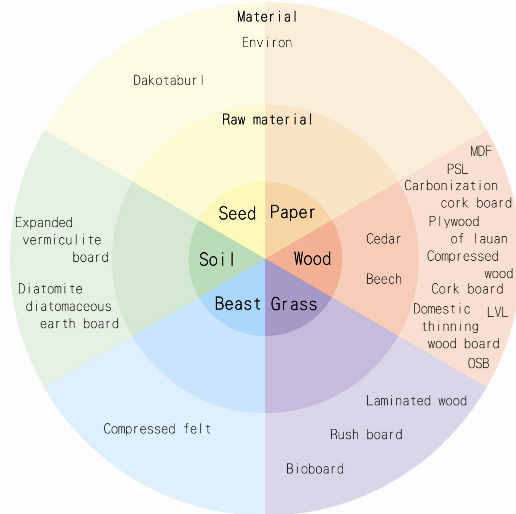


Fig.2 Kinds of sample

Fig.3 Surface from of sample

Fig.4 Situation of sight experiment

Fig.5 Situation of touch by foot experiment

2.2 RESULT OF EXPERIMENT

Factor analysis was performed on the data. The factors related to the sense by vision, touch by hand, and touch by were extracted. Moreover, configuration mapping of the materials evaluated piece was conducted. Next, cluster analysis was performed to classify the materials into similar groups.

2.3 RESULT OF FACTOR ANALYSIS

First, the result of the factor analysis of the data obtained by vision is described. The materials with an absolute value of factor loading of 0.5 or more were further interpretated. Given the number of factors and the reduced number of characteristic values, it was judged that 5 factors were suitable. The accumulation contribution rate after varimax rotation was 66.5%. The 1st factor was named "quality factor," the 2nd "volume factor," the 3rd "familiarity factor," the 4th "freshness factor," and the 5th "showiness factor."

Next, the result of the factor analysis of the data obtained through touch by hand is described. Similar to the factor analysis of the data obtained by vision, the materials with an absolute value of factor loading of 0.5 or more were further interpretated. Given the number of factors and the reduced number of characteristic values, it was judged that 5 factors were suitable. The accumulation contribution rate after varimax rotation was 65.5%. The 1st factor was named "quality factor," the 2nd "volume factor," the 3rd "familiarity factor," the 4th "freshness factor," and the 5th "showiness factor" the same result as those for the data obtained by vision.

Lastly, the result of the factor analysis of the data obtained through touch by foot is described. Similar to the factor analyses of the data obtained by vision and the data obtained through touch by hand, the materials with an absolute value of factor loading of 0.5 or more were further interpretated. Given the number of factors and the reduced number of characteristic values, it was judged that 5 factors were suitable. The accumulation contribution rate after varimax rotation was 63.6%. The 1st factor was named "quality factor," the 2nd "familiarity factor," the 3rd "weight factor," the 4th "freshness factor," and the 5th "showiness factor," which are different from those for the data obtained by vision and by hand touch. The factor loadings after varimax rotation are shown in Tables 1 - 3. Table 1 shows the factor loading after varimax rotation of the data obtained by vision, Table 2 shows the data obtained through touch by hand, and Table 3 shows the data obtained through touch by foot.

2.4 CONFIGURATION MAP BETWEEN FACTORS AND RESULT OF CLUSTER ANALYSIS

In order to identify and compare the sensory characteristics of the materials piece in terms of some of the factors, configuration maps were produced on the basis of the 1st factor and the 2nd factor, and on the basis of the 1st factor and the 3rd factor, that the factor loadings of which were high. Furthermore, cluster analysis was performed. Fig. 6 provides the configuration maps on the data obtained by vision: ① the 1st factor (quality factor) and the 2nd factor (volume factor), ② the 1st factor (quality factor) and the 3rd factor (familiarity factor). Fig. 7 provides the configuration maps on the data obtained through touch by hand: ① the 1st factor (quality factor) and the 2nd factor (volume factor), ② the 1st factor (quality factor) and the 3rd factor (familiarity factor). Fig. 8 provides the configuration maps on the data obtained

Table1 Factor loading after varimax-method(Sense of Sight)

	Factor1	Factor2	Factor3	Factor4	Factor5
elegance/ inelegance	0.8767	−0.0059	0.0637	−0.0095	−0.0168
cleanliness/ un cleanliness	0.8285	−0.0233	−0.1031	0.0953	−0.1037
exclusive/ cheap	0.6425	0.2439	0.2095	−0.0725	0.3093
new/ old	0.6220	−0.0655	0.1600	−0.2669	0.3538
mellow/ rough	0.6040	0.2765	−0.0588	0.1031	0.0850
coarse/ fine	−0.6010	−0.1028	0.1198	0.3342	0.3112
heavy/ light	−0.0139	0.8977	0.0299	−0.1232	−0.0484
strong/ weak	0.1688	0.8712	−0.0419	0.0933	−0.0510
hard/ soft	0.1325	0.6967	−0.4004	0.0738	−0.0182
elastic/ inelastic	−0.1002	−0.1637	0.7983	−0.0143	−0.0794
wet/ dry	0.4153	0.1735	0.5470	−0.1974	0.1776
warm/ cool	0.0556	−0.2164	0.5352	0.4601	−0.0830
natural/ artificial	0.0202	0.0972	−0.0892	0.8400	0.0518
artless/ sophisticated	−0.2188	−0.0295	0.0937	0.5318	−0.4996
showy/ inconspicuous	−0.0237	−0.0995	−0.0437	0.0343	0.8740
Construction of factors	Quality factor	Volume factor	Familiarity factor	Freshness factor	Showiness factor
Sum of squares	3.262	2.326	1.507	1.478	1.402
Contribution rate(%)	21.744	15.503	10.044	9.851	9.347
Accumulation contribution rate(%)	21.744	37.247	47.291	57.143	66.490

Table2 Factor loading after varimax-method(Sense of touch by hand)

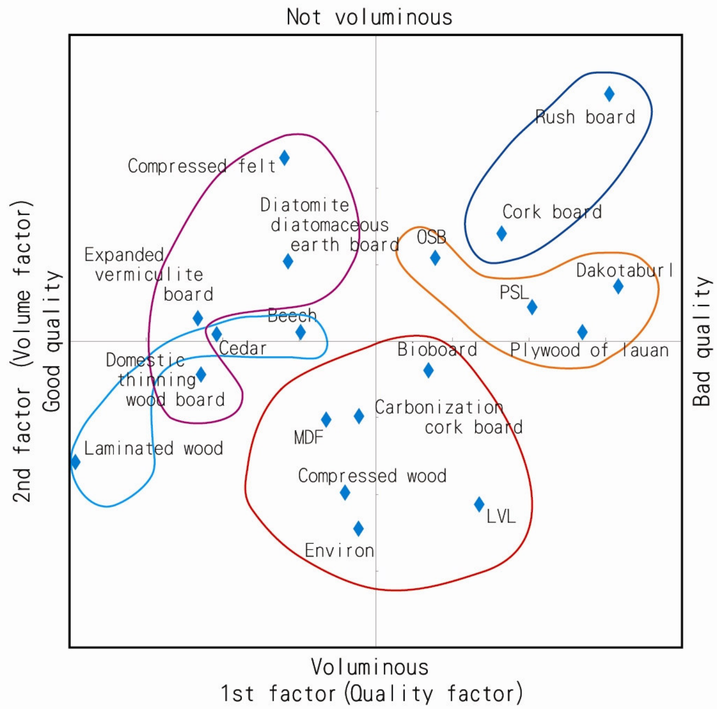
	Factor1	Factor2	Factor3	Factor4	Factor5
elegance/ inelegance	0.8200	0.0682	0.0765	−0.1142	−0.0588
cleanliness/ un cleanliness	0.7968	−0.0284	−0.1565	0.0695	−0.1297
exclusive/ cheap	0.7252	0.1814	0.1203	−0.0855	0.2395
new/ old	0.6601	−0.0849	0.1013	−0.2881	0.2587
mellow/ rough	0.5686	0.3224	0.0661	0.0791	−0.1356
heavy/ light	0.0057	0.8749	−0.0652	−0.0754	0.0336
strong/ weak	0.1943	0.8294	−0.0968	0.0219	−0.0946
hard/ soft	0.1140	0.6095	−0.6088	0.0597	0.0512
elastic/ inelastic	−0.0457	−0.2986	0.7735	0.0067	−0.0437
wet/ dry	0.3253	0.2078	0.7001	−0.0645	0.0335
warm/ cool	−0.0111	−0.0791	0.6015	0.3347	−0.0223
natural/ artificial	−0.0105	0.0801	0.0142	0.7960	0.0110
artless/ sophisticated	−0.1451	−0.0884	0.1092	0.7503	−0.0693
showy/ inconspicuous	0.0402	−0.0149	−0.0582	−0.0739	0.8978
coarse/ fine	−0.4987	−0.1145	0.0221	0.3760	0.4217
Construction of factors	Quality factor	Volume factor	Familiarity factor	Freshness factor	Showiness factor
Sum of squares	3.023	2.141	1.910	1.584	1.168
Contribution rate(%)	20.151	14.271	12.733	10.558	7.787
Accumulation contribution rate(%)	20.151	34.422	47.155	57.713	65.500

Table3 Factor loading after varimax-method(Sense of touch by foot)

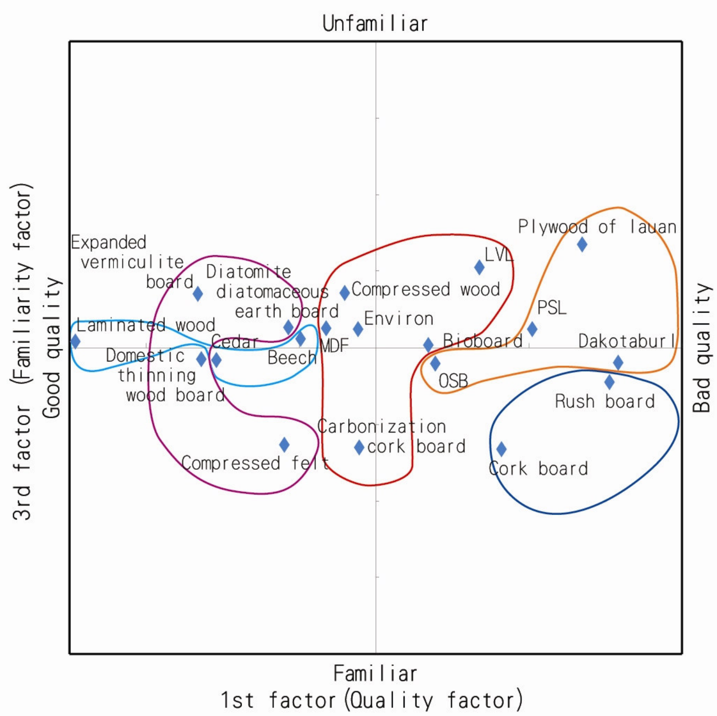
	Factor1	Factor2	Factor3	Factor4	Factor5
elegance/ inelegance	0.8441	0.0498	−0.0083	−0.0711	−0.0639
cleanliness/ un cleanliness	0.7368	−0.2109	0.0281	0.1761	−0.2026
exclusive/ cheap	0.7146	0.1677	0.0615	0.0235	0.1018
new/ old	0.6810	0.0699	−0.0980	−0.1529	0.1681
mellow/ rough	0.6280	−0.1348	0.3258	0.1052	0.1334
coarse/ fine	−0.5261	−0.0298	−0.2377	0.3536	0.1577
elastic/ inelastic	0.0056	0.7851	−0.0910	0.0035	−0.0964
warm/ cool	0.0383	0.6549	−0.0481	0.2895	−0.0268
wet/ dry	0.4567	0.5007	0.1861	0.0160	0.2661
hard/ soft	0.0910	−0.7014	0.4258	0.1332	−0.0584
heavy/ light	0.0079	−0.0626	0.8657	−0.0693	−0.0133
strong/ weak	0.1428	−0.1795	0.8082	0.0835	−0.1106
natural/ artificial	0.0452	0.0235	0.1241	0.8010	0.1107
artless/ sophisticated	−0.1057	0.1559	−0.0921	0.6947	−0.3252
showy/ inconspicuous	0.0321	−0.0280	−0.1202	−0.0519	0.8998
Construction of factors	Quality factor	Familiarity factor	Weight factor	Freshness factor	Showiness factor
Sum of squares	3.154	1.949	1.844	1.437	1.151
Contribution rate(%)	21.025	12.992	12.295	9.577	7.672
Accumulation contribution rate(%)	21.025	34.018	46.313	55.890	63.561

through touch by foot: ① the 1st factor (quality factor) and the 2nd factor (familiarity factor), ② the 1st factor (quality factor) and the 3rd factor (weight factor). The features of each materials in each configuration map are described below.

First, in Fig. 6, ① the configuration map based on the 1st factor (quality factor) and the 2nd factor (volume factor) shows that laminated wood of bamboo was the best in quality and good in volume, and rush board was the worst in quality and lacking in volume. In addition, the materials that were good in terms of the quality factor were the soil materials such as expanded vermiculite board and diatomite diatomaceous earth board, the solid wood materials such as cedar and beech, and the wood composite material of domestic thinning wood board. The materials lacking in quality factor were the seed material of dakotaburl, the wood composite of lauan plywood and PSL, etc. The materials related to the volume factor were the paper material and seed material of environ, the compress-processed cedar material of compressed wood, and the wood composite of LVL. The materials lacking in volume factor

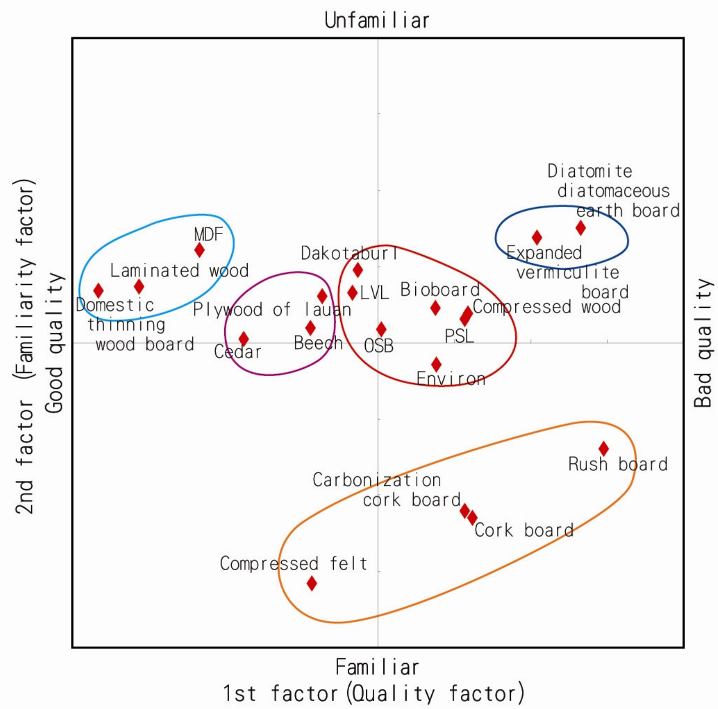


①1st factor-2nd factor

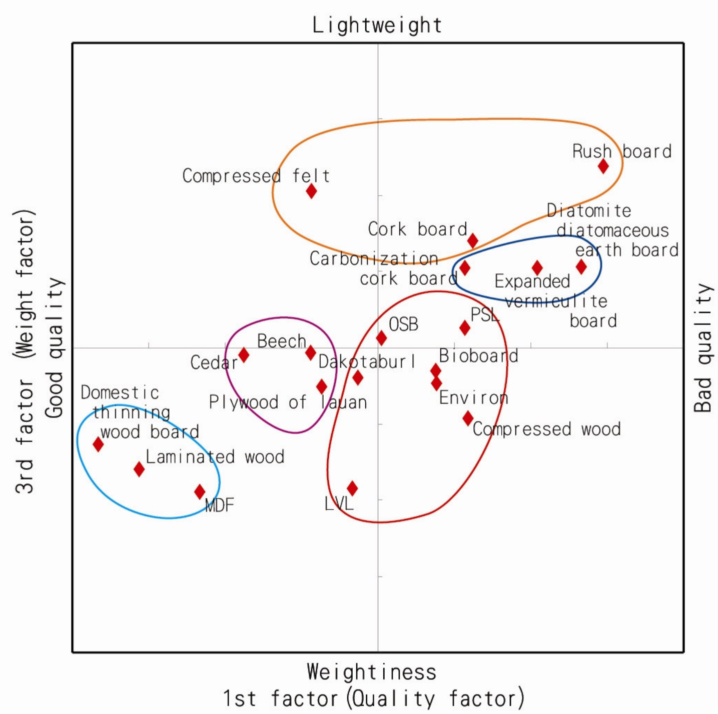


②1st factor-3rd factor

Fig.6 Configuration map of each sample in sight were compressed felt and cork board. Cluster analysis. Of the data yielded the 5 groups shown in the dendrogram in Fig. 9. ①. These were allocated in the configuration map based on the 1st factor and the 2nd factor. As a result, it was established that the 1st group was the solid wood material group of cedar, beech, and laminated bamboo wood, the 2nd group was the high density group of expanded vermiculite board, diatomite diatomaceous earth board, domestic thinning wood board, and compressed felt, the 3rd group was the uniform element group of environ, carbonization cork board, bioboard, and compressed wood, MDF, and LVL, the 4th group was the low density group of lauan plywood, dakotaburl, OSB, and PSL, and the 5th group was the lightweight group of rush board and cork board. In the configuration map based on the 1st factor (quality factor) and the 3rd factor (familiarity factor) of Fig. 6. ②, the same as the configuration map based on the 1st factor and the 2nd factor, laminated bamboo wood was the best in terms of the quality factor, and expanded vermiculite board, diatomite diatomaceous earth board, domestic thinning wood board, and cedar were also good. Rush board,



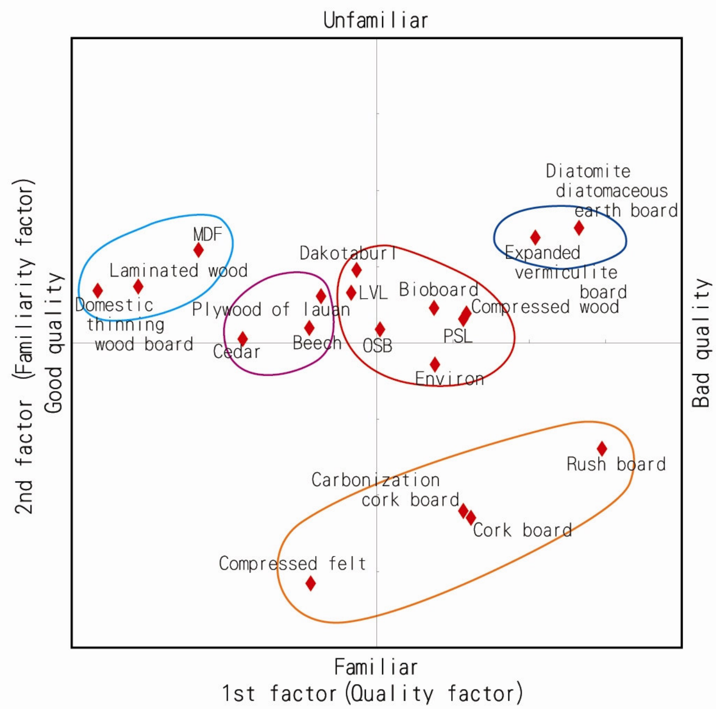
①1st factor-2nd factor



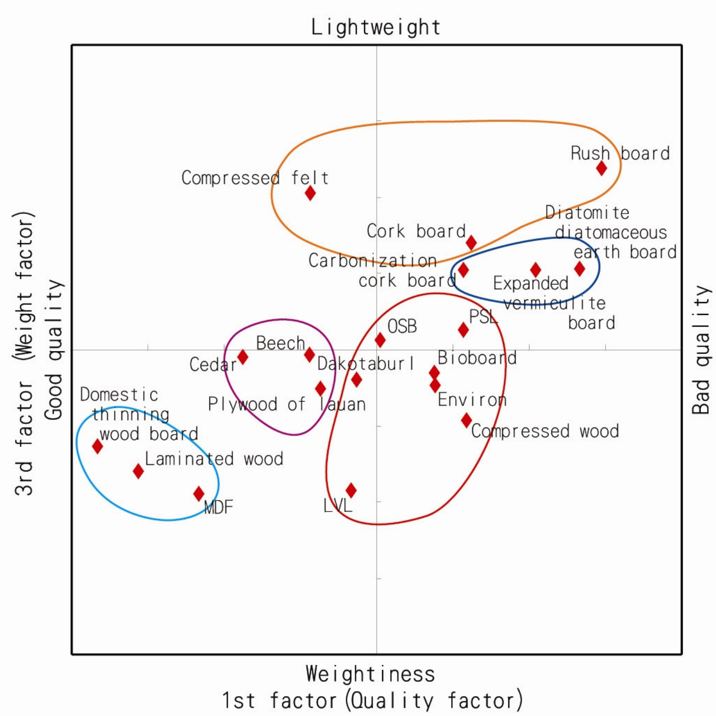
②1st factor-3rd factor

Fig.8 Configuration map of each sample in sense of touch by foot dakotaburl, plywood of lauan, and PSL were lacking in quality, and this result was the same as that of the configuration map based on the 1st factor and 2nd factor. It was concluded that although there was no big variation in terms of the familiarity factor, compressed felt, cork board, and carbonization cork board were good in familiarity.

Fig. 7 provides configuration maps on the data obtained through touch by hand. Configuration map ① based on the 1st factor (quality factor) and the 2nd factor (volume factor), laminated bamboo wood, domestic thinning wood board, and MDF were good in quality and volume, rush board was lacking in quality and position volume. Other than these materials, no big variation was seen in terms of the quality factor. In terms of the volume factor, it was established that compressed felt, cork board, and carbonization cork board were lacking in volume factor, and LVL, compressed wood, and environ were good. Cluster analysis of the data from produced the 5 groups shown in the dendrogram in Fig. 9 ②. It turned out that the 1st group was the wood material group of



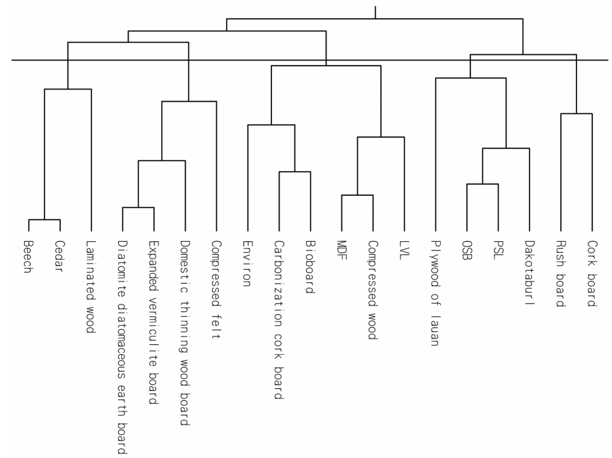
①1st factor-2nd factor



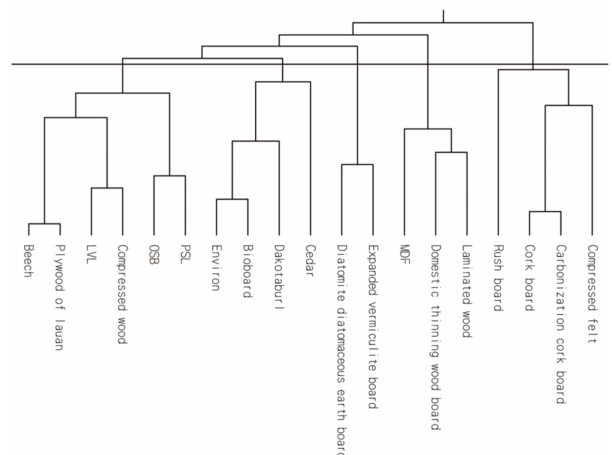
②1st factor-3rd factor

Fig.8 Configuration map of each sample in sense of touch by foot beech, lauan plywood, compressed wood, LVL, OSB, and PSL, the 2nd group was the element uneven group of environ, bioboard, dakotaburl, and cedar, the 3rd group was the soil material group of expanded vermiculite board and diatomite diatomaceous earth board, the 4th group was the high density group of MDF, domestic thinning wood board, and laminated bamboo wood, and the 5th group was the lightweight group of rush board, cork board, carbonization cork board, and compressed felt. Configuration map ① based on the 1st factor (quality factor) and the 3rd factor (familiarity factor), in the same way as the configuration map ② based on of the 1st factor and the 2nd factor, it turned out that laminated bamboo wood, domestic thinning wood board, and MDF were good in quality and rush board was lacking in quality. As for the familiarity factor, compressed felt, cork board, and carbonization cork board were good, and the other materials neutral.

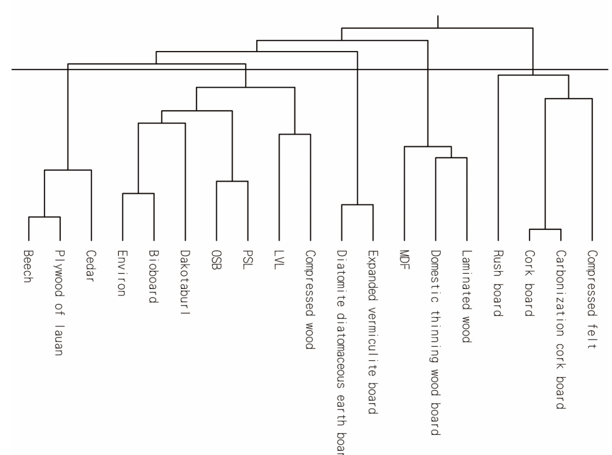
Fig. 8 provides configuration maps of the data obtained through touch by foot. Configuration map ① based on the 1st factor (quality factor) and the 2nd factor (familiarity factor), shows that laminated bamboo wood, domestic thinning wood board, MDF, and cedar were good in terms of the quality factor, and expanded vermiculite board, diatomite diatomaceous earth board, and rush board were lacking in quality factor. As for expanded vermiculite board and diatomite diatomaceous earth board, although they were evaluated as good in quality through the sense of



①Sense of sight



②Sense of touch by hand



③Sense of touch by foot

Fig.9 Dendrogram

vision only and the sense of touch by hand, they received the opposite evaluation through the sense of touch by foot. As for the materials reduced to the familiarity factor, although compressed felt, cork board, carbonization cork board, and rush board were good in familiarity, many of other materials evaluated were neutral. Cluster analysis of the data identified the 5 groups shows in the dendrogram in Fig. 9 ③. These 5 groups were allocated in the configuration map based on the 1st factor and 2nd factor. The 1st group was the wood material group of cedar, beech, lauan plywood, the 2nd group was the compression molding group of environ, bioboard, dakotaburl, OSB, PSL, LVL, and compressed wood, the 3rd group was the soil material group of expanded vermiculite board and diatomite diatomaceous earth board, the 4th group was the high density group of laminated wood of bamboo, domestic thinning wood board, and MDF, and the 5th group was the lightweight group of rush board, cork board, carbonization cork board, and compressed felt. Configuration map ② based on the 1st factor (quality factor) and the 3rd factor (weight factor) of ②, in the same way as the configuration map based on the 1st factor and 2nd factor shows that laminated bamboo wood, domestic thinning wood board, and MDF were good in quality, and rush board and diatomite diatomaceous earth board were lacking in quality. LVL, MDF, and laminated bamboo wood were good in weight, and rush board, compressed felt, and cork board were lacking in weight.

3. MATERIAL COLOR

In order to characterize the material color of each test material, chromaticity was measured by using a color difference meter. The meter used was a handy color difference meter NR-3000 Type A, made by NIPPON DENSHOKU INDUSTRIES CO., LTD., and L*a*b* color system was measured.

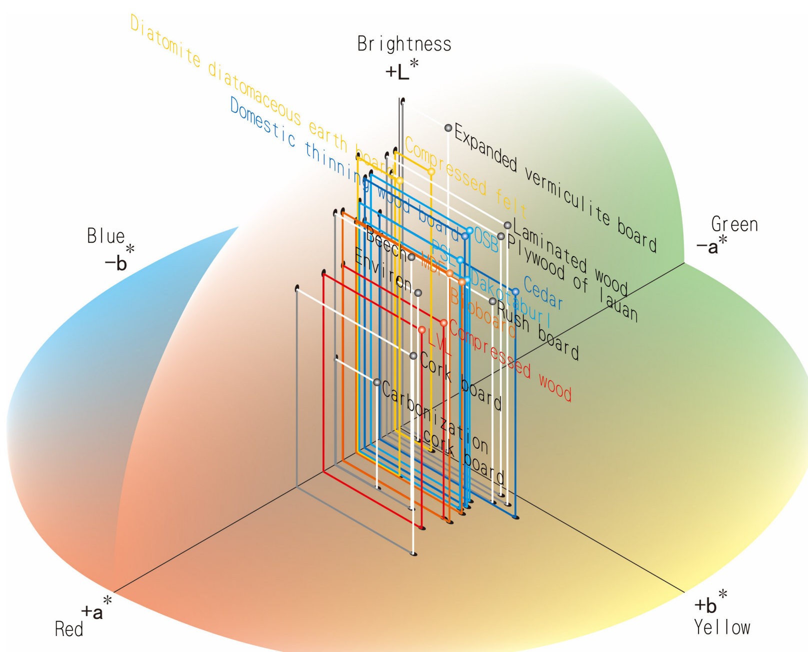


Fig.10 Chomatisity of sample on color solid

The measuring method is described below. The surface of each piece of material was divided into 9 blocks. The central part of each block was measured, and the average was considered as the color of the material. The light source used this time was standard illuminant D65 (approx. 6.504 K/equivalent to daylight illuminant) as specified in JIS-Z-8720.

The measurement result is shown in Fig. 10. This shows the average chromaticity of each piece of material allocated to the color solid of the L*a*b* color system. This figure shows that although each material had a different brightness, there was no big difference at Y and YR in hue and they were very similar. Moreover, relating this to the configuration map based on the 1st factor and 2nd factor generated from the data obtained by vision described in section 2.2.2 (Fig. 10), it turned out that the materials in the approximately similar positions on the color solid were also allocated in approximately similar positions in the configuration map.

4. SURFACE FORM

In order to clarify the surface form of the materials, they were magnified and photographs were taken, and assessed. For photographing, a video microscope, DS-3NL made by Micro Square Co., Ltd. was used. As for the photographed part of each material, a part where the features of the material were judged to be clear was selected. The magnification of the video microscope was set to 50 times (the view range of 5.2 $\times$ 4 mm),
which could distinguish the elements
constituting each material. The photographs produced were incorporated into the configuration map described in section 2.2.2, and the influences of the form of each material on the sense of vision or the sense of touch were examined.

Fig. 11 shows the results of the evaluation by vision, Fig. 12 shows the results of the evaluation through the sense of touch by hand including the sense vision. Fig. 13 shows the results of the evaluation through the sense of touch by foot including the sense vision. /// thuse free figures were adapted from configuration maps based on the 1st factor and the 2nd factor. In the sense by vision as shown in Fig. 11, laminated bamboo wood, domestic thinning wood board, expanded vermiculite board, and etc. turned out to be good in quality, of high density by appearance, and with colors that were almost uniform. Rush board, lauan plywood, dakotaburl, and etc were lacking in quality, of low density and with directions or color of the element form were not uniform. Fig. 12 shows that the high density materials by appearance were judged through touch to be better in quality. It was established that environ, compressed wood, LVL, etc. were good in the volume factor as evaluated through the sense of vision and the sense of touch by hand. These materials an had the common characteristics of high density and dank color. Fig. 13 shows that the materials with large element forms were good in terms of the familiarity factor. As for the quality factor, similar the evaluation through the sense of vision and the sense of touch by hand, it was established that the materials of high density were good in quality.

5. CONSIDERATION

In this research, board-shape environment conscious materials made from natural materials were examined and the visual characteristics of the materials were clarified so that appropriate materials would be selected appropriately as interior materials. The evaluations were made through the sense of vision, the sense of touch by hand, and the sense of touch by foot, and judgment on the materials color and surface form. First, in the sensory evaluation, the interpretation of the data obtained by vision and that through the sense of touch by hand turned out to be the same, and that through the sense of touch by foot turned out to be different from them. Given these results, it can be said that for floor materials the sense of touch by foot is important. When selecting interior materials, it is necessary to check the sense of touch by foot. Relating the results of chromaticity measurement to

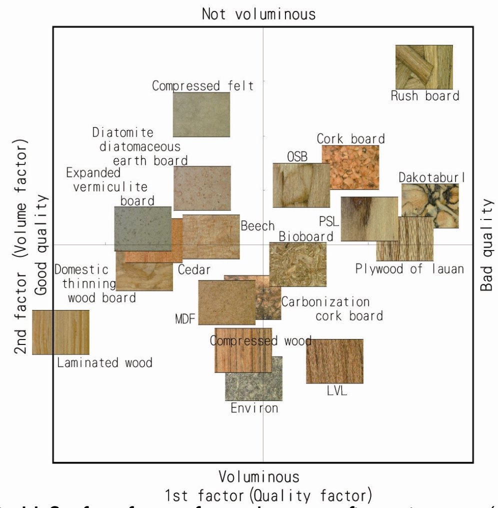


Fig.11 Surface form of sample on configuration map(sense of sight)

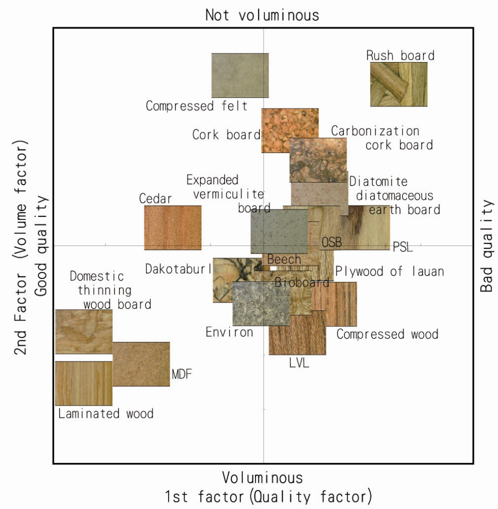


Fig.12 Surface form of sample on configuration map(sense of touch by hand)

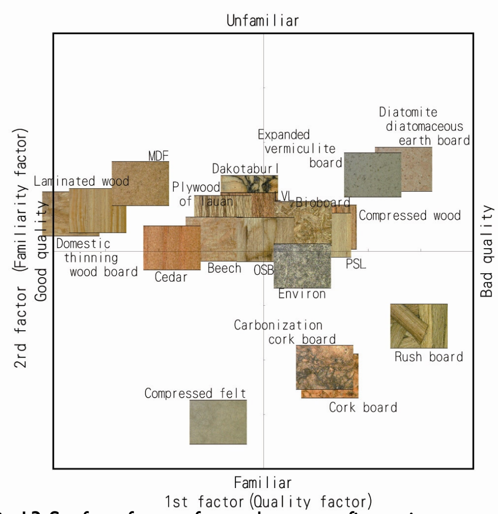


Fig.13 Surface form of sample on configuration map(sense of touch by foot)

the configuration map of the data obtained by vision showed that many of the materials that had similar chromaticity were allocated in similar positions in the configuration map. From this, it can be judged that the sense of vision is greatly influenced by the materials color. Moreover, it was established that, as for chromaticity, although each material had a different brightness, all the material were alike in hue, and not so many of them had individuality in terms of color. Take wood composite as an example: when using it as a component for furniture, fittings, and interiors, since many wood composites are made from heartwood materials, dressed lumber is applied on the surface. Therefore, the color of the material itself is not examined. However, environment conscious materials made from natural materials are expected to be used independently, not covered with dressed lumber. From this, it can be considered that the colors of environment conscious materials also serve as an important factors in material selection. Relate the surface form of each material to the configuration maps, it was established that although in the sense by vision and the sense of touch by hand, the materials of higher density were better in quality. As evaluated through the sense of touch by foot the materials with large element forms were better in terms of the familiarity factor. Thus, it can be said that the senses of vision and touch by hand differ from and the sense of touch by foot as factors in material selection, and the surface form also serves as an important factor.

6. CONCLUSION

In this research, it became clear that in order to appropriately select environment conscious materials as interior materials, sense by vision, touch by hand, and touch by foot, material color, and surface form as visual character become important factors. However, the factors related to the visual character contain the elements such as surface coarseness, hardness, and the degree of wear. It is considered that the experiments for these are necessary to be added from now on. Furthermore, in order to complete the database for interior materials selection, it is necessary to clarify the mechanical character, physical character, and character for processing of materials, besides their visual character. Taking these into consideration, future assignments are to clarify the effective usage method of the board-formed environment conscious materials made from natural materials.

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