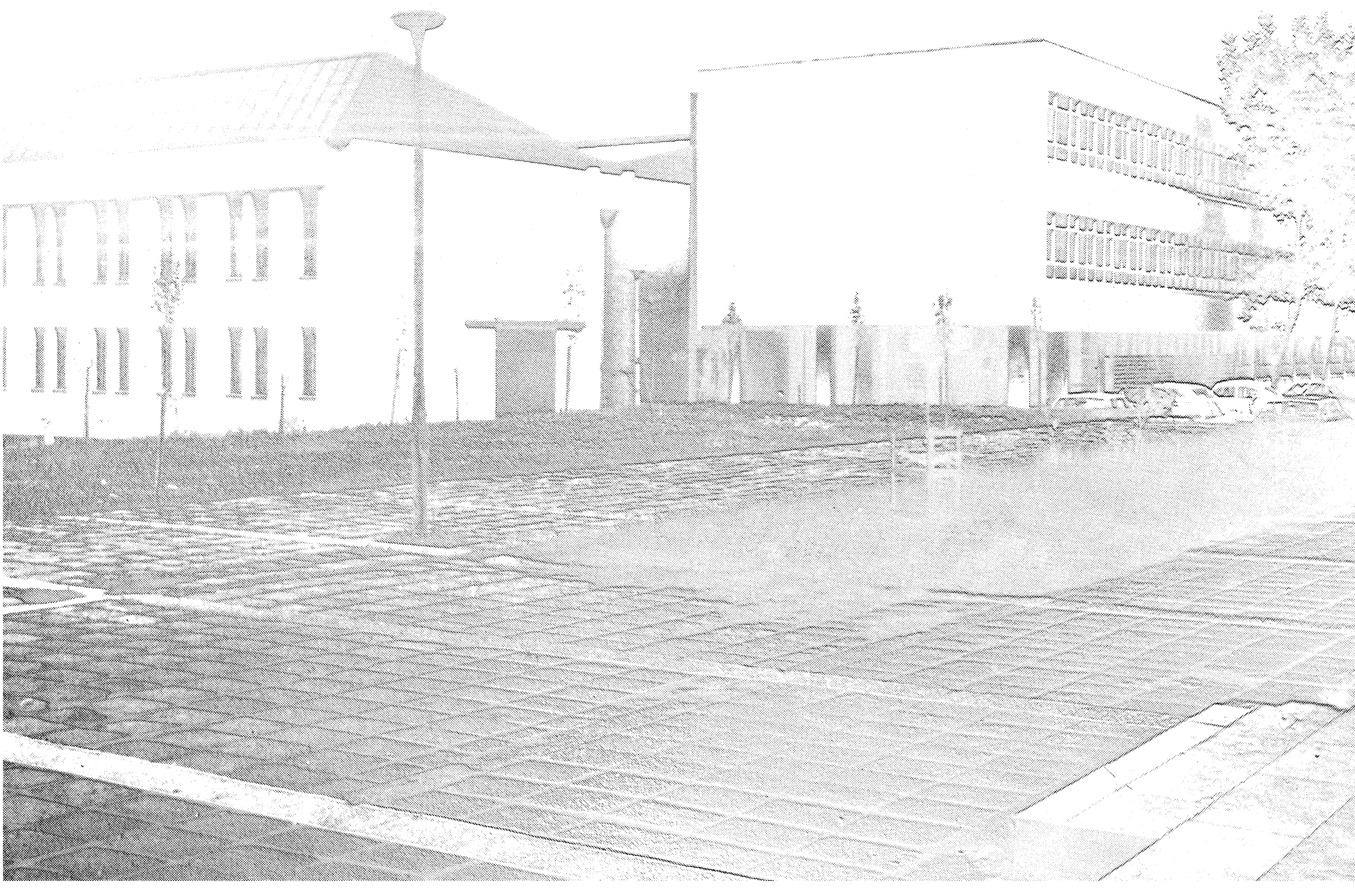
KARADENİZ TEKNİK ÜNİVERSİTESİ MİMARLIK BÖLÜMÜ

MİMARLIK BÜLTENİ

KARADENİZ TECHNICAL UNIVERSITY DEPARTMENT OF ARCHITECTURE



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Teknik Yönetmen
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Uzm. Hasan Saltık

Yazışma
Correspondance
Orhan Topsakal

Yazı—Dizgi
Typing
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Address for orders and other correspondance :

Orhan Topsakal
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KTÜ.Mimarlık Bölümü
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Prof. Dr. Yalçın YAŞAR
KTÜ - Mimarlık Fakültesi
Dekanı

KARADENİZ GAZETECİLİK VE MATBAACILIK A.Ş.
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CONTENTS

A METHOD FOR SELECTING BUILDING PRODUCTS TO PERFORM THE SAME FUNCTIONS REQUIRED BY USER

Dr. ERTAN ÖZKAN

SUMMARY

As a result of industrialisation, the number of building products which perform the same functions is rapidly increasing. Due to this fact the selection of the most suitable building products becomes an important problem for user.

The paper deals with development of a method for the selection of the most suitable building products to perform the same functions required by the user. The method basically has four phases as follows :

- Setting up the objectives, constraints, criteria and the alternatives ; then establishing the relationships among them by pairs and as a whole, to form a base for evaluation.

- Evaluation is achieved by measuring the performance properties of alternatives by using a specific scale and by defining them by single unit which is user's " benefit ". Regardless of the system used in measuring the properties performed by alternatives, their values must be converted to " benefit ".

- The comparison of the sums of the " benefits " obtained by alternatives meeting the same functional requirement is nevertheless insufficient for comparing them. This is due to the fact that the degree of " importance " changes according to the relationships among objectives, criteria and alternatives in connection with the user requirements.

- Therefore the real "benefit value" which gives the overall-worth of a building product can only be obtained by multiplying the "benefit" values of it with the corresponding degrees of " importance ". As a result, the highest "benefit value" which is yielded by an alternative is the best or the most suitable alternative to meet the user requirements.

INTRODUCTION

The potential of industrialisation in building rapidly increases the number of feasible building products which perform the same functions. Similarly, as the user activities and the quantity of equipment utilized in them increase, requirements become correspondinly more and more complex.

The selection of the most suitable product from among the numerous alternatives produced to meet certain requirements becomes a critical problem in the design process. Because of the increase in the number of user requirements and the product alternatives, it is almost impossible to make a proper intutive decision.

SELECTION OF BUILDING PRODUCTS

The ultimate goal is to develop a method for identifying and evaluating products which perform the same functions in the built-environment, then selecting from product alternatives the most suitable once for the user requirements.

A system for selecting building products can be achieved by modify ing the phases of decision making - problem solving methods without changing their structure, (1), (2), (3) . This can be done by:

- Defining and formulating the problem - defining the ultimate goal and identifying the elements involved in the selection,
  - Setting up objectives and constraints
  - Setting up alternatives
  - Setting up criteria.
- Constructing the conceptual model - establishing relationships among the elements,
- Deriving the solution through evaluation, comparison and the final selection of the most suitable alternative from among the building product alternatives,
- Testing the model and the preferred alternative.

Relationships among the above phases with the elements in each phase are conceptually established through an ' output model ' developed by the ' systems approach ' . Fig. 1.

SETTING UP THE ELEMENTS FOR SELECTION

For setting up the elements which will take part in the selection process, it is found that classifying and coding the objectives, constraints, alternatives and criteria appear necessary, but they are inadequate. The reasons for this are the following :

- The external and internal environmental factors and the user requirements, which bring forth the elements for selection have to be defined systematically for the setting up of objectives and constraints or criteria.

- Owing to the fact the building product alternatives are so numerous, it appears impossible to classify them. For this reason, a method must be developed to classify the ' building system variables ' in facets. To set up the product alternatives, the facets are then integrated.

As a result, to set up the elements properly, it must be considered firstly external factors and user requirements. Then objectives, constraints, " building system variables " and the properties which might be used as criteria are classified and coded. The " faceted classification " theory is taken as a base for this purpose.

Setting up Objectives and Constraints

Objectives are the purposes for which the selection among the alternatives are made. Thus they become selfimposed guidelines that bound the selection. The alternative which will be selected can only be the most suitable building product where it is used, if the objectives and constraints bring correct restriction in selection process. For this reason objectives have to be defined and set up systematically, in accordance with the user · s physiology, psychologic and sociologic characteristics, the user activities, external factors and the relation between the selected alternative and the other building products which are used together with it, (4). The classifying and coding of objectives can be done as the following :

Da General
b Objectives related to user
c Useability, serviceability - related dimension, area, space
d Social and ethical convenience - privacy etc.
e Comfort
f Health - protection
g Safety - protection
h Aesthetic appreciation, satisfaction

Dk Objectives, related to building products
l Feasibility, ease of building
m Useability) related to the products
n Flexibility, interchangeability) used together with the
o Suitability) alternative.

p Ease of maintenance
r Durability
---
u Resource allocation suitability
v Economy

All set up objectives neither have the same value nor take part in every product selection. To express the fact that the level of importance has to be established among the objectives for each selection, (5).

The constraints give dimensions to limit the objectives and describe how they are to be attained. For this reason, the constraints directly depend on the objectives and are set up in accordance with them.

The combination of objectives and constraints constitute restriction which take part in rules, specifications and standards in accordance with their degree of importance and generality.

Setting up Alternatives

Building product alternatives which meet all or some of the requirements expected from the built-environment in physical and/or functionaldimensions have to be known in detail. On account of the impossibility of classifying all the product alternatives the building systems are classified.

In the last two decades, many building classification systems have been developed for various reasons, such as SfB, CBC, BSAB,CLASP BIC systems etc. However, it is found that their related tables have been not set apart according to the stage of completion of the products that they also do not give the possibility of expressing all the building product alternatives in detail.

To solve the problem, each variable of the building system is classified and coded in a separate ' facet ' and spread over a wide area in the first step, (6). Thus, a flexibility is provided in formulating the building product alternatives by supplementing different ' facets' with each other without using certain coding nests. For this purpose a building system's variables classification system is structured as the following :

.	Physical Level	Ka-Kz	Materials - Basic constituent product as undefined mass
		Ma-Mz	Parts- defined mass which is independent from specific function
		Na-Nz	Components
		Oa-Oz	Elements
		Pa-Pz	Units
.	Physical - Functional Level	Sa-Sz	Structural sub- systems
		Ta-Tz	Basic functional elements sub- system
		Ua-Uz	Services sub- system
.	Functional Level	Va-Vz	Building spaces und sub- spaces
		Ya-Yz	Building.

Setting up Criteria

Criteria are the means by which alternatives are measured, and, consequently, they define how the objectives are to be judged. Thus criteria illustrate the relative conformance or degree of accomplishment of each alternative, in terms of the objectives.

In the selection the performance requirements which are to be met by the properties of the building products take part as criteria. However every property which is shown by the products may not be used as criterion, because the importance any criterion is dependent on the requirements ant the related factors.

Nevertheless in consequence of the impossibility of setting up the criteria beforehand for each case of product selection, the desired properties of building products as performance requirements are classified in accordance with the stage of completion of the products, so that ones are used as criteria in each case. To meet the needs, varions lists and classification facets have been set up in relation to the properties of building products, as a list of performance requirements and the internal structure of products, (7), CI/SfB Systems-Table 4, Sweet ' s Guide Lines (8), etc.
However in most cases, either only the properties of metarials have been considered or the reasons for setting up those lists and facets have been different. On the other hand, it is emphasized that the user requirements and the related factors are taken as the base for setting up the expected properties of building products as performance requirements. (4).

.s a result, in setting up the expected properties for each stage of ompletion of building products in accordance with the user require-ıents and external factors, the following structure can be used:

Za General
 b Descriptive properties - dimension, weight, color etc.
 c Properties related directly to the user activies,

Zf Heat, properties related to,
 g Water, water vapour and other liquids,
 h Sound,
 i Air, other gases and smell,
 j Light and radiation,
 k Electricity,
 l Solids

Zn Products and equipment
 o Strength and stability,
 p Fire,
 r Biological agents,
 s Production, assembly and building,
 t Operation and maintenance,
 v Resource allocation,
 y Economy.

CONSTRUCTION OF THE RELATIONSHIPS MODEL

In order to use the objectives and criteria correctly when evaluating the product alternatives in selection process, the appropriate relationships have to be established among them, Fig. (1).

First of all the relationships among the objectives, alternatives and criteria are established by pairs as the following:

Relationships Between Objectives and Criteria

The objectives and criteria have mutual relationships basically, because the criteria define how the objectives are to be measured or judged. In addition they have both been set up according to the user requirements and the environmental factors to take part in the selection process. These relations are guidelines in the evaluetion process to calculate the right ' total value ' of the products.

Relationships Between Objectives and Alternatives

Building products are designed and produced to meet certain requirements and factors which have been set up as objectives at the highest level. However, these relations are only set up through the properties of products, which are the criteria.

Relationships Between Criteria and Alternatives

The building products have many properties, but some of them become important when they take part in built-environment.These properties are used as criteria which in addition have degrees of importance among themselves.

- Relationships Among the Products

The relations are to be arranged in a hierarchy which depends on the stage of completion of building products. They are set up in three ways, as physical, physical- functional and only functional, Fig. (2). These relationships among the building products are used as guidelines for the evaluation of product alternatives.

These relationships among the objectives, alternatives and the criteria are integrated on three dimensional matrices to establish a base for the evaluation process, Fig. (3).

DERIVING A SOLUTION

For deriving a solution, product alternatives are evaluated and compared. Then the alternative, which is the most suitable for used in the built- environment, is finally selected from among the products which perform the same functions.

The Evaluation of Product Alternatives

Products are designed or produced to meet certain objectives.Thus, the overall worth of a product is found by the addition of the values which are obtained by measuring the performance of the product in achieving the objectives in accordance with each criterion.

Products can easily be evaluted according to each property, by using the connected performance testing method and expressing the results with its own scale and the unit. Also it can be easily decided which one is the most suitable alternative among the product alternatives, if only one property is taken into account as a criterion, (9).

A single measure of the overall worth of a product is needed in order to compare it with the other product alternatives. On the other hand, the evaluation of the overall worth of a product is a multidimensional problem which seems difficult to solve for the following reasons :

- Most of the properties of the products are measured with different scales and units

- Mostly, the unit value of a scale which is used to measure a performance of the product does not have the same value at all intervals in the scale in accordance with the user requirements

- The objectives and also criteria do not have the same degree of importance with respect to each other, in accordance with the user requirements.

As a result, in order to make the right selection of the most suitable alternative from among the product alternatives which perform the same function, an approach is proposed for evaluation of the overall worth of each product alternatives.

The first phase of the evaluation process is to measure all performance properties of building products by using a single scale and describing by a single unit. By taking ' benefit ' as the unit, and the ' interval scale ' as the scale, with the assumption that the most beneficial alternative among the product alternatives is the most suitable one for the user requirements. It is actually possible to establish an analytic correlation between the values of performance property and levels of benefit which is a measure of user gain according to the corresponding objectives, (10), (11).

Thus, regardless of the system or scale used in measuring the performance properties of the products they have to be converted to ' benefit '. This conversion is obtained by measuring the ' benefit value : W ' provided to the user and corresponds to the required values of the performance properties of the Products under defined environmental factors. The ' performance property- benefit ' correlation can thus be established as a curve, Fig. (4). This will be done by field studies : surveys, interviews, observation etc., and laboratory research. When the figure is examined, two general results are noticed about the ' performance property-benefit ' correlation :

- The value of a performance property which is up to a certain degree :
  ' Fo ' does not yield any ' benefit '. This value will be equal to the relative zero for the ' benefit '.

- The value of a performance property which is more than the limit value :
  ' Fxm ' does not raise the ' benefit value : W '. This value is expressed by ' 2. 0 ' relative value and which can be named as ' maximum benefit value '.

Thus, it becomes possible to obtain the user's ' benefit ', yielded by a product alternative performing in a certain ' built-environment', by making use of the correlation between the values of performance property and the ' benefit '.

External and internal environmental factors change according to the basic function of the built- environment, time, place etc. The effects of these changes on the built-environment will influence the performance property-benefit correlations which are prepared one by one as separate curves depending on the value intervals of environmental factors, Fig. (5).

DEGREE OF IMPORTANCE OF OBJECTIVES, ALTERNATIVES AND CRITERIA

Knowing only the ' benefits ' yielded by the product alternatives meeting the same function in the built-environment is nevertheless insufficient for comparing the alternatives. This is due to the fact that degree of level of importance changes among objectives with respect to each other in connection with the user requirements, and also similar relationships are among criteria and-sub-alternatives that constitute the alternative. This can be explained the following :

- The degree of importance of the objectives differ with recpect to each other in meeting certain user requirements under certain environmental factors. For this reason, degrees of importance of objectives have to take part in the evaluation process to reflect the degrees of importance of user requirements for the overall worth of the product alternatives.

- Degrees of importance of sub-alternatives which constitute an alternative depend on the relationships between objectives and alternatives, because each sub-alternative has a different effect in meeting an objective.

- In the evaluation of the worth of an alternative in relation to an objective, not every property of building products is always taken as a criterion. Also the degrees of importance of all criteria differ with respect to each other.

In line with these opinions, it is necessary to determine the degrees of importance among the objectives and also sub-alternatives and criteria in order to evaluate the overall worth of the product alternatives for the selection of the most beneficial alternatives. Degrees of importance of objectives and also others are expressed by their relative importance with respect to each other. For example, the degree of importance of an objective is accepted as q=1.00 and the others are found by pair comparison with it. When the overall worth of each product alternative in the ' benefit scale ' -between 0.0 and 2.0- is calculated by multiplying the degrees of importance and the benefit values of the sums of the degrees of importance : q have to be equal to one as the following :

$$q = q_1 + q_2 + q_3 + \ldots + q_n = 1.00$$

CALCULATING THE OVERALL WORTH OF PRODUCT ALTERNATIVES AS ' BENEFIT '

By using measurement techniques, it thus becomes possible to e - uate the overall worth of building products from physical, physical-functional and functional points of view and to compare them in order to select the most beneficial ones for the user.

The following is an example of the calculation of the overall worth of a building product :

Od External wall element,

- Nd1 Structural component
- Nd2 External surface component
- Nd3 Internal surface component
- Nd4 Window component

External wall element will be evaluated by addition of the calculation of the overall worth of each component as a sub-product.

Calculations at the Level of Component

For the evaluation the ' benefit values ' of the components and the degrees of importance of criteria and the components have to be determined firstly as the following :

From the ' performance property - benefit ' correlation graphs the ' benefit values : W ' of each component are found in accordance with each criterion and the corresponding objectives. For example :

Ndl - Structural component

Objectives	' Benefit values ' according to criteria
Dc : Usability	W_{Zb}, W_{Zc}, W_{Zd}, ..., W_{Zy}
De : Comfort	W_{Zb}, W_{Zc}, W_{Zd}, ..., W_{Zy}
.....	
Dy : Economy	W_{Zb}, W_{Zc}, W_{Zd}, ..., W_{Zy}

The number of the ' benefit values ' is as great as the multiplication of the number of objectives and the performance properties of the component. But this number becomes so small in reality, because neither all objectives take part in every selection nor all performance properties are used as criterion.This process has to be done for the other components.

The degrees of importance of criteria according to the corresponding objectives are expressed as following :

According to one objective :

$$\sum_{x=b}^{y} q_{Zx} = q_{zb} + q_{zc} + q_{zd} + \ldots + q_{zy} = 1$$

According to all objectives .

$$\sum_{w=c}^{v} \sum_{x=b}^{y} q_{Zx , Dw} = 1$$

The degrees of importance of components are also expressed as following :

According to one objective :

$$\sum_{x=b}^{y} \sum_{z=1}^{4} q_{Ndz,Zx} = 1$$

According to all objectives :

$$\sum_{w=c}^{v} \sum_{x=b}^{y} \sum_{z=1}^{4} q_{Ndz,Zx,Dw} = 1$$

Evaluation at the Level of Element

The first phase of the evaluation is the multiplication of the benefit values of components by the degrees of importance of criteria and components to find the worth of components in accordance with each objective. The calculation of the worth of each component is done as the following :

$$W_{Ndz,Dw} = \sum_{x=b}^{y} W_{zx} \cdot q_{Zx} \cdot q_{Ndz,Zx}$$

At the second phase, the worth of all components are added to find the worth of the element in accordance with the same objectives as the following :

$$W_{Od,Dw} = \sum_{z=1}^{4} W_{Ndz,Dw} = 0 \longrightarrow 2$$

The worth of element in accordance with the all objectives is expressed :

$$W_{Od,Dw} = \sum_{w=c}^{v} \sum_{z=1}^{4} W_{Ndz,Dw} = 0 \longrightarrow 2$$

The last phase of the evaluation is the multiplication of each worth of element by the degrees of importance of the objectives to find the overall worth of the element which can be calculated as the following:

- The degrees of importance of objectives :

$$q_{Da} = \sum_{w=c}^{v} q_{Dw} = 1$$

- The overall worth of the element :

$$W^{t}_{Od} = \sum_{w=c}^{v} W_{OdDw} \cdot q_{Dw} = 0 \longrightarrow 2$$

<u>Comparison and Selection</u>

A selection is done by comparing the overall worth of the alternatives which are thought to perform the same functions in the built-environment. In the selection the highest 'W^{t} - overall worth' as 'benefit' which is yielded by the alternative is the best or the most beneficial alternative to meet the user requirements.

CONCLUSION

By knowing the benefit values of building product alternatives in accordance with the criteria and the corresponding objectives and the degrees of importance of objectives, sub-alternatives and criteria, it becomes possible to calculate the overall worth of the other alternatives.

The method which is basically the classificiation and coding of elements of the selection system and the evaluation of building products, provides the first impetus for further studies as the following :

- To enable the producers to prepare information about their products and to evaluate them in accordance with the user requirements.

- To arrange the performance property-benefit correlation graphs to obtain the benefit values of products in accordance with each criterion.

- To determine standard performance testing methods to enable the benefit values of products to be found through the same processes in every laboratory.

- To feed computer with information data related to the objectives, constraints, alternatives and the criteria, so that the computer can be used to evaluate, compare and make the final selection.

REFERENCES

(1) Churchman, C.W., Ackoff, R.C., Arnoff, E.L., Introduction to Operations Research, John Wiley and Sons Inc., New York, 1968

(2) Rivett, P., Principles of Model Building - The Construction of Models for Decision Analysis, John Wiley and Sons, London, 1972

(3) Optner, L.S., System Analysis for Business and Industrial Problem Solving, Prentice Hall, Englewood Cliffs, N. J., 1965

(4) Cronberg, T., Saeterdal, A., From Surveys to Performance Tests, The Impact of Research on the Built Environment, CIB 6th Congress, Budapest, 1974

(5) Riggs, J.L., Economic Decision Models, Mc Graw-Hill Book Co., Tokyo, 1968

(6) Özkan, E., Yapım Sistemlerinin Seçimi için Bir Yöntem, PhD Thesis, İstanbul Technical University, Faculty of Architecture, İstanbul, 1976

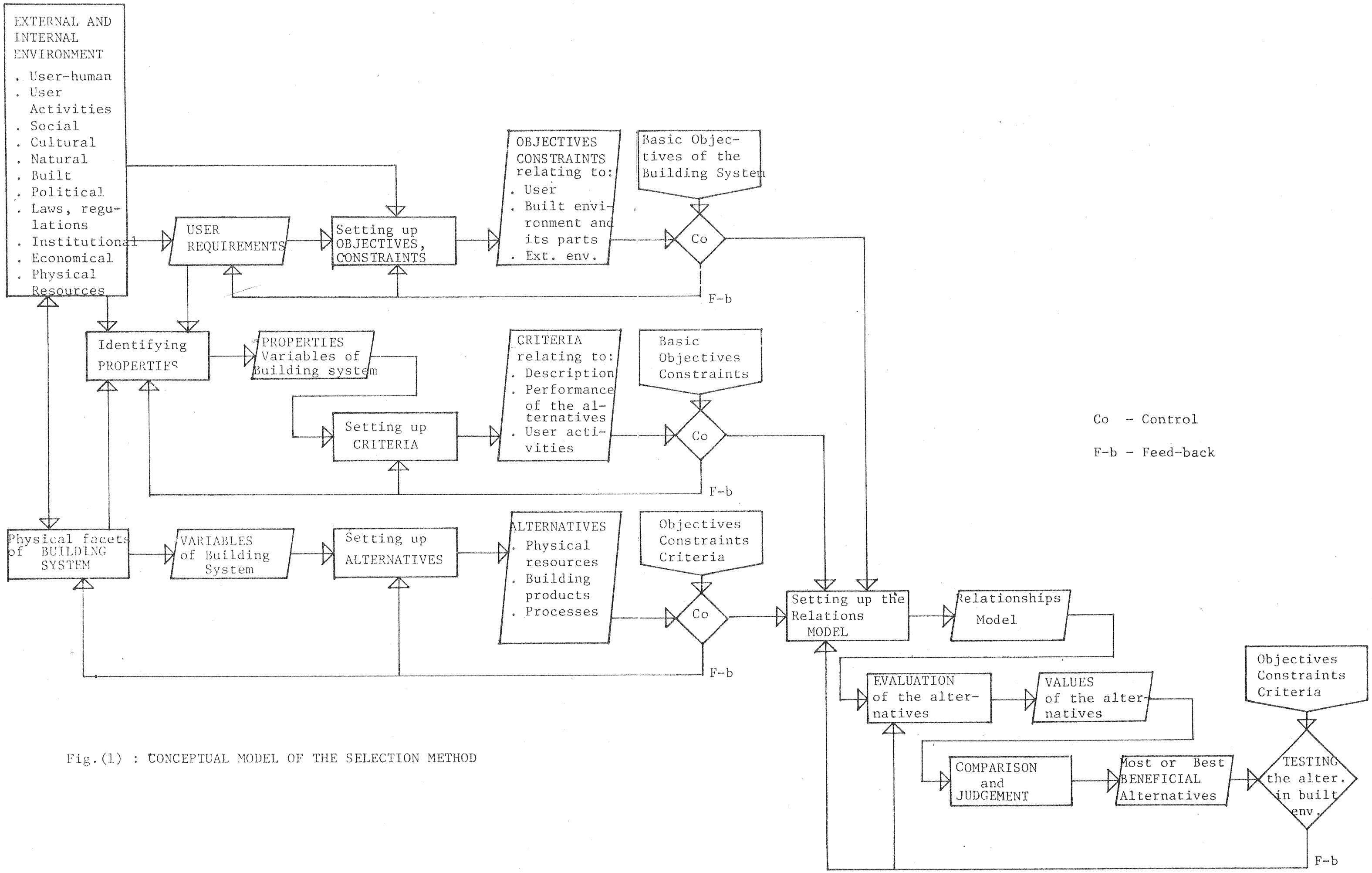
(7) Sneck, T., Koshi, L., Saarimaa, J., Performance Analysis Check Lists 1970 The State Institute for Technical Research Laboratory of Building Technology, Otaniemi, 1970

(8) Anon., Sweet ' s Refines Logic of the Product Search, Sweet's Division, Mc Graw-Hill Information Systems Company,New York, 1973

(9) Shiriyama, K., Nirekli, T., Performance Criteria for Panelised Interior Finish for Public Owned Flats, The Impact of Research on the Built-Environment, CIB 6th Congress, Budapest, 1974

(10) Parsons, J.D., Performance : The New Language of Design, Performance Concept in Building, NBS Special Publ. 361, U. S. Dept. of Commerce, Washington, 1972

(11) Bouchin, K.T., Performance Specification for Housing, The Impact of Research on the Built Environment, CIB 6th Congress, Budapest, 1974.



Co - Control

F-b - Feed-back

Fig.(1) : CONCEPTUAL MODEL OF THE SELECTION METHOD

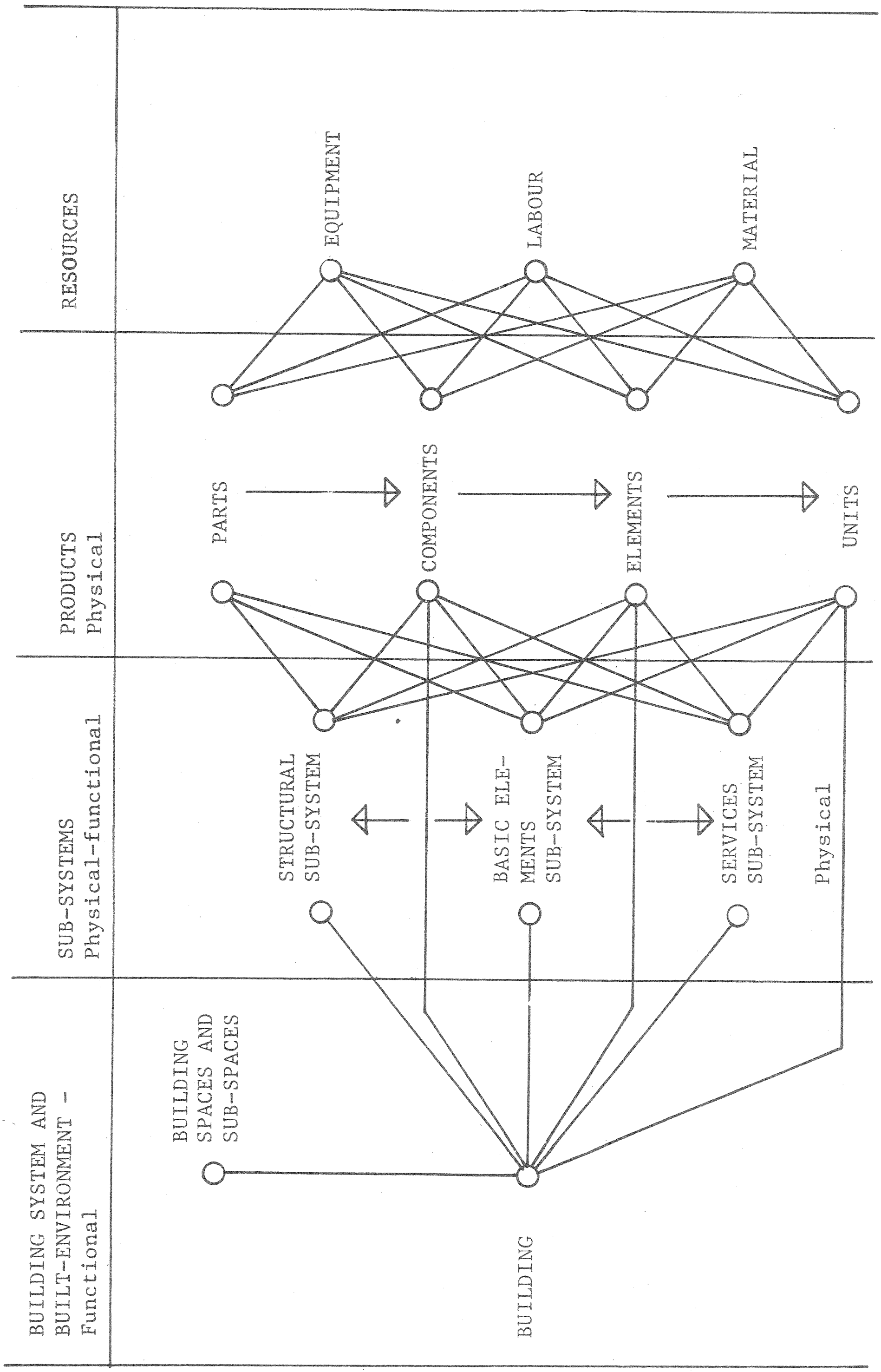


Fig.(2) : RELATIONSHIPS BETWEEN BUILDING PRODUCTS

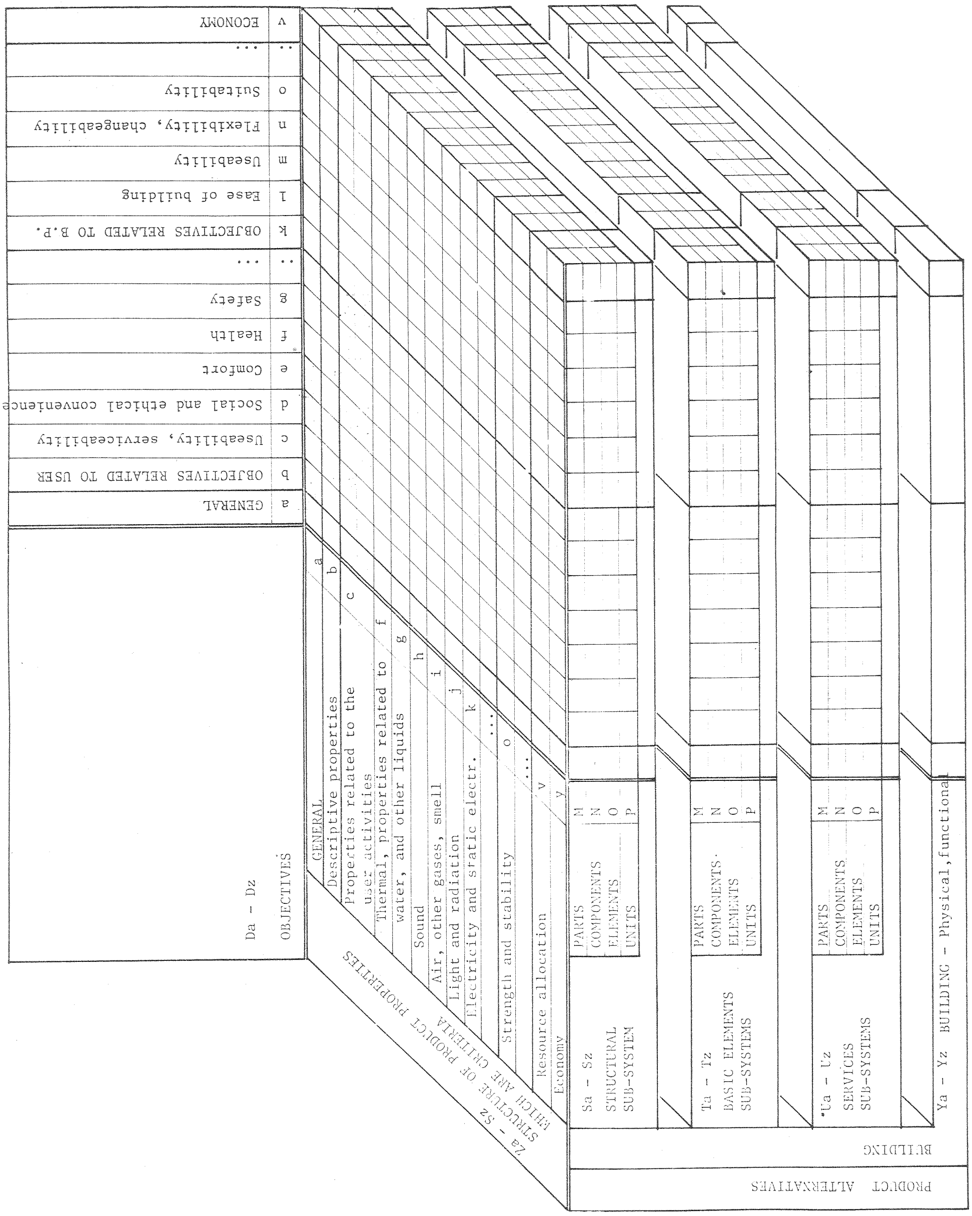


Fig.(3) : THE RELATIONSHIPS AMONG THE OBJECTIVES, CRITERIA AND PRODUCT ALTERNATIVES

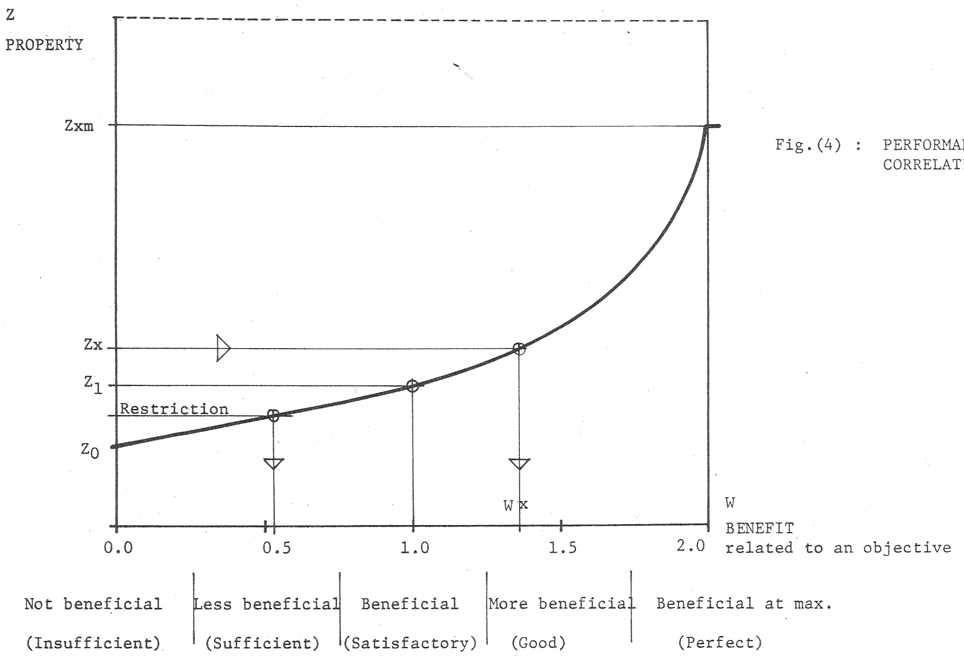


Fig.(4) : PERFORMANCE PROPERTY - BENEFIT CORRELATION

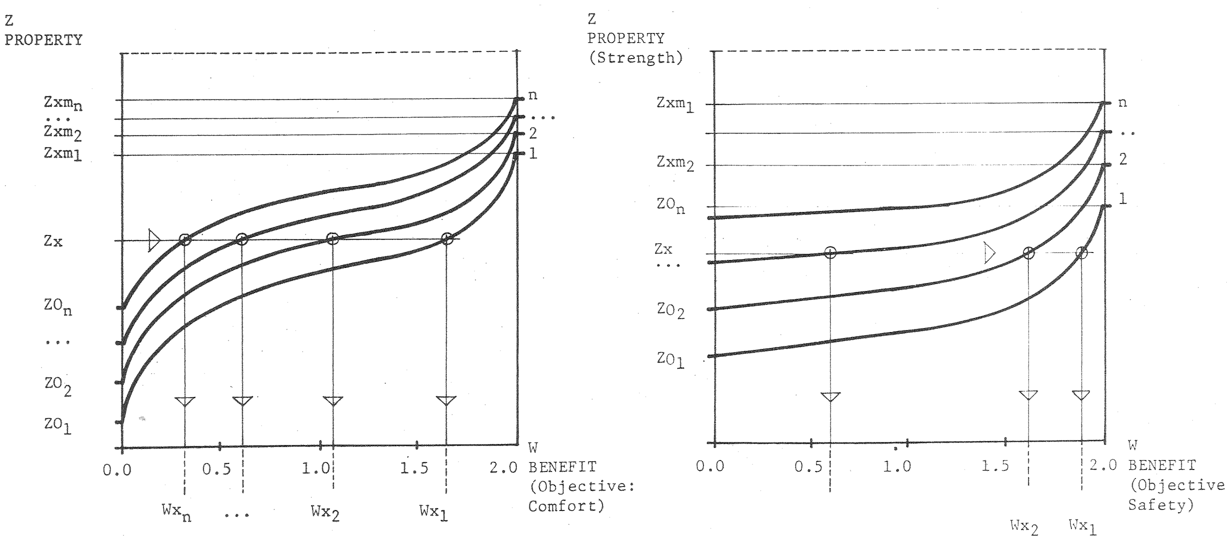


Fig.(5) : PERFORMANCE PROPERTY - BENEFIT CORRELATIONS

THE EFFECT OF HUES OF WALLS ON THE PERCEIVED MAGNITUDE OF SPACE IN A ROOM UNDER TWO DIFFERENT LIGHT SOURCES HAVING DIFFERENT SPECTRAL ENERGY DISTRIBUTION

Dr. ERDAL AKSUGÜR

(1) Introduction

Studies of space perception from the sensory point of view are of long standing. Very few studies, however, have been concerned with the experimental investigation of space perception from an architectural point of view. There are some unsolved problems between man and the visual properties of physical environment " which affect perceived magnitude of a single space. " Color is one of the most important properties of the physical environment which still has many unknown effects on the visual perception of space.

The present study was concerned with the effect of the hues of walls on the perceived magnitude of space in relation to the spectral qualities of different light sources. This study consisted of three parts.

In the first part, the visual properties of the physical environment which affect the " perceived magnitude of space " is examined in the three different perception modalities. They are : light perception , form perception and color perception. The examined visual properties are determined as follows, referring to the previous studies :

--Luminance of wall surfaces-- Sky luminance seen from the window--Average illuminance level in interior--homogeneity of the illuminance level in interior--Dimensions of the room--Proportions of the room--Shapes of the walls--Texture characteristics of the wall surfaces--Size, shape and position of the window--Size of the equipment and furniture--Furniture density--Spectral characteristics of the light sources--Color characteristics of the wall surfaces-- Color characteristics of the furniture.

The second part of this study dealt with two color properties of the physical environment. These were color characteristics of the wall surfaces and spectral characteristics of the light sources. Previous experimental approaches on these color properties were examined. These examinations showed that previous studies considered the surface color and the spectral characteristics of the light sources separately, and they neglected color distortions due to several unexpected factors, color shifts due to multiple interreflections in a room.

Starting from these examinations, in the third part, a new experimental method was suggested. For this method the main aims were determined as follows :

- To study the effect of hues of walls on the " perceived magnitude of space in a room " under two different light sources having different spectral energy distribution.
- To study the relations between wall color preferences of the subjects and their subjective evaluations on the " perceived magnitude of space " in a room.
- To determine whether architectural education gives some preconceptions of the evaluation of space under the color and light variables.

For obtaining satisfactory results applicable to the real life at the end of this study, the following decisions were made :

- To consider surface color and light source variables together.
- To use scale models for controlling all the variables affecting perceived magnitude of space.
- To choose the independent variables between the most common colors of interior walls and between most common interior light sources.

(2) Method

(2.1) The Surface Color Variables.

At the first step, the " User's Color Preferences Graphic for the Interior Walls of the Building " was prepared, obtaining data from the indexes of paint sales of the last three years in Turkey. The Munsell Book of Color was used to describe colors. Four colors, were chosen from this graph (see Figure 1) . Munsell Values of these four chosen colors were equal ; Munsell Chromas of them were also made equal. So only " Hue " differences were taken as one of the independent variables. Their Munsell notations were : 10 B 9/2, 2.5 G 9/2, 7.5 Y 9/2 and 5 R 9/2 (see Figure 2) . In addition, to obtain a standard condition " Neutral Grey " (Munsell Value 9)was used on the wall surfaces. On the floor Neutral Grey (Munsell Value

7, reflectivity 0.40) was used. Only for a pilot study to obtain the differences of the color shifts on the walls due to multiple interreflections, floor colors were made the same color as the walls.

(2.2) The Light Source Variables.

In this study one of the main aims was to choose the light source variables between the most common light sources. As a result of investigations, it was seen that between fluorescent light sources "20 W Daylight Fluorescent Tube, " and between tungsten filament light sources " 60 W Tungsten Filament Lamp " were most common in Turkey. Their qualifications were as follows (see Figures 3 and 4) ·

- Daylight Fluorescent Tubes ; 20 W, 1150 lm, correlated color temperature 6500 ^{o} K, chromaticity coordinates on the CIE Chromaticity Diagram ; x=.306, y=.324.
- Tungsten Filament Lamp ; 60 W, 630 lm, color temperature 2790 ^{o} K, chromaticity coordinates on the CIE Chromaticity Diagram ; x= .456, y=.412.

(2.3) Apparatus.

In architectural psychology, previous studies which were directly or indirectly related to the " perceived magnitude of space " stated that scale models were satisfactory means to study the visual aspects of spaces. They mentioned that the scales of models didn't affect the magnitude estimation of the perceived space and models were satisfactory means to study artificial lighting.

These previous studies gave the idea of using scale models as stimulus. Two fifth-scale models of a room were constructed to eliminate " memory factor " on the magnitude estimation. The dimensions of these model room were : 60 cm wide, 80 cm deep and 60 cm high They were formed with their one short back wall, two long side walls and the floor (see Figures 5 and 6) . Over the ceiling opening of each model room, a matte white reflector which contains light sources was placed as a lighting system. One of the short walls served as an observation opening. In the middle of the back wall, the door of the room was drawn with its contourline. At fifth-scale, the dimensions of this door were 18 cm wide and 42 cm high. During the observations, subjects focused their views at the middle of the this door-contour to get the same angle of view for the two model rooms. At the same time this door-contour gave an important perceptual cue to the subjects to imagine these empty boxes as model rooms.

The walls were changeable hardboard plates. The inner surfaces of these plates were colored with chosen mat paints.

(2.4) Lighting System.

In order to obtain the same luminance patterns on the different wall surfaces having the same Munsell Value and reflectivity, it was sufficient to get a uniform illuminance distribution on these surfaces. For this purpose it was decided to illuminate the two model rooms from their ceiling openings. Three " daylight fluorescent tubes " (20 W, 1150 lm) and six " tungsten filament lamps " (60 W, 630 lm) were placed inside of a matte white reflector designed for each model room. These lighting systems were suspended the ceiling of the experiment room, over the ceiling opening of each model, with pulleys. These could be moved vertically up and down to control the illuminance inside of the model rooms. Illuminance measurements were made using " Gossen Panlux " luxmeter, which had nearly the same spectral sensitivity as the human eye. While the illuminance was taken as 2000 lx at the middle of the floor surface, the other measurements were 1680 lx at the near corner of the floor, 1740 lx at the opposite corner of the floor, 1900-2050 lx at the middle of the side walls and 2070 lx at the upper part of the walls.

(2.5) Experiment room.

The two model rooms were placed in a dark room having a width of 2.40 m and a length of 3.20 m, side by side, so that their horizontal axis converged and met at a distance of 1.80 m. From this point, at the same horizontal plane with the ceilings of model rooms, subjects observed these two model rooms in order to compare them. Between the two model rooms and on the same vertical plane with the " open short walls, " black curtains were hung to eliminate undesirable visual cues and reflections. This curtain hat two 60 cm x 60 cm openings at the same places with the open short walls of the model rooms (see Figure 6).

Except for the two chosen independent variables, all visual properties which affect perceived magnitude of space in a room were controlled by eliminating or equilizing them.

(2.6) Subjects.

Between 44 volunteers, 42 subjects (21 male and 21 female) having normal color vision were selected using " Ishihara Test of Color Blindness. " Two volunteers were dichromat; they had "Deuteranopia " (red-green color blindness). The subjects were taken in two groups. Twenty-three subjects were architects and students of architecture (median age, 21.8), nineteen subjects were civil engineers, psychologists, secretaries and employees (median age, 24.6). We called this second group " non-architects. "

(2.7) Procedure.

The work was executed in three phases.

(2.7.1) Phase 1. In the first phase, color shifts on the wall surfaces of model rooms due to multiple interreflections under " Tungsten Filament " and " Daylight Fluorescent " light sources were determined using " memory method for color matching. " Munsell Book of Color, Neighboring Hues Edition, Matte Finish Collection was used for color samples.

Six observers were selected from forty-two subjects. The Munsell Book of Color and the method for color matching were explained to these observers. In the experiment room, The Munsell Book of Color was placed under the light beam coming from the northeast sky through the opening (25 cm x 25 cm) in the black-painted window of the experiment room. The angles between incident light and surface of the color samples, and between observers' viewing direction and surface of the color samples were 45^{o}. The distance between observers ' eyes and color samples was taken 25-30 cm.

The middle part of one side-wall of one model room was observed for evaluating surface color shifts. Each observer entered the experiment room with the author, and for five minutes looked at wall surface and color samples, then decided which color sample had the same appearance with the apparent color of wall surface. The Munsell Notation of this color sample was taken. Each observer fulfilled this process for four " color variables " under the two " light source variables " with neutral grey and colored floors. On the colored floor conditions, the floor was in the same value, hue and chroma with the walls.

At the end of these processes, color shifts on the wall surfaces of model rooms due to multiple interreffections under "tungsten filament " and " daylight fluorescent " light sources were determined. These color shifts were listed with their chromaticity coordinates on the CIE Chromaticity Diagram (see Table 1) and were shown on the Munsell Hue and Chroma circle for Munsell Value 9 (see Figures 7 and 8) .

(2.7.2) Phase 2. In this phase all the possible combination pairs between " hue " and " light source " variables were taken in six groups to compare by the method of paired comparison. These combinations were listed below with the following abbreviations : GR, Grey; R, Red; Y, Yellow; G, Green; B, Blue; t, under tungsten filament lamps; f, under daylight fluorescent tubes.

Group 1. Both of the model rooms had "grey walls " and illuminated with different light sources.

Model Room I	Model Room II
GR_t	Gr_f

Group 2. Both of the model rooms were illuminated with " tungsten filament lamps, " one of the model rooms had " grey walls " and the other one, " colored walls "

Model Room I	Model Room II
Gr_t	R_t
GR_t	Y_t
GR_t	G_t
GR_t	B_t

Group 3. Both of the model rooms were illuminated with " daylight fluorescent tubes, " one of the model rooms had " grey walls " and the other one, " colored walls. "

Model Room I	Model Room II
GR_f	R_f
GR_f	Y_f
GR_f	G_f
GR_f	B_f

Group 4. The walls were the same color in both of the model rooms and one of the model rooms was illuminated with "tungsten filament lamps, "the other " daylight fluorescent tubes. "

Model Room I	Model Room II
R_t	R_f
Y_t	Y_f
G_t	G_f
B_t	B_f

Group 5. Both of the model rooms were under "tungsten filament lamps," but the colors of the walls were different.

Model Room I	Model Room II
R_t	B_t
R_t	G_t
R_t	Y_t
Y_t	B_t
Y_t	G_t
G_t	B_t

Group 6. Both of the model rooms were under " daylight fluorescent tubes, " but the colors of the walls were different.

Model Room I	Model Room II
R_f	B_f
R_f	G_f
R_f	Y_f
Y_f	B_f
Y_f	G_f
G_f	B_f

During the tests, in order to obtain " rightleft balance, " the color and light source variables were inter changed from one model room to another, and for getting random order for the paired comparisons, each subject participated in each paired comparison in a different order.

(2.8) Tests.

Each subject entered the experiment room while the author was present, sat down in the adjustable seat, placed his eyes on the observation point, which was represented by the knot of a cord hanging from the ceiling of the experiment room, and heard some introductory instructions concerning the test procedures. The experiment room was completely dark except inside of the two model rooms.

- After two or three minutes ' observation, the subject was asked if there was any difference between " perceived magnitudes of spaces " on the two model rooms.
- If the subject did not perceive any difference, or perceived equal " the magnitudes of spaces, " the author wrote " O " on the " difference evaluation list and the subject left the experiment room, to be followed by another subject.
- If the subject perceived any difference, he was asked to estimate the percentage of difference, considering perceived spatial magnitude of small apparent model room as " one hundred. " This numerical magnitude difference estimation was written in the column under big apparent model room on the difference evaluation list. The subject left the experiment room, to be followed by another subject.

Each subject evaluated each combination pair indicated above and these evaluations were listed for each group of paired comparisons (see Table 2) .

(2.7.3). Phase 3. At the third phase, four sheets (6 cm x 6 cm) colored in the chosen color variables were shown to each subject individually on a matte black background. The subject rank ordered these four colors under " Natural Daylight " according to their preferences for the walls of a living room.

(3) Results

(3.1) First Group Analysis.

The evaluations of the 42 subject for each paired comparison were treated by χ^2 (chi-square) Significance Test according to their frequencies. If the distribution of frequencies was significant ($p \leq 0.05$) , the mean of the difference percentages was accepted as " Difference between Perceived Magnitudes of Spaces " under this specific condition. If the distribution of frenquencies was not significant ($p > 0.05$) the " Difference between Perceived Magnitude of Spaces " was accepted " 0 " (zero). These findings were shown with graphs (see Figures 9, 10, 11 and 12).

The first group of results can be summarized as follows :

- Between the two model rooms having the same color on the walls, the perceived magnitude of space on the model room illuminated by the " daylight fluorescent " tubes was greater than the one illuminated by the " tungsten filament " lamps (see Figure 10) .
- Comparing the two model rooms, illuminated by the same light sources, the model room having blue walls gave the greatest " space perception. " Green, yellow and red followed, respectively. Only under " tungsten filament " lamps did the subject not perceive any difference between the two model rooms having green and yellow walls (see Figure 11) .

The perceived magnitudes of spaces depended on " Apparent Hues " of walls, which are results of the color shifts under the two type light sources.

All the numerical differences obtained from each paired comparison were calculated according to the other paired comparisons considering perceived spatial magnitude of " grey-walled " model room under " tungsten filament " light source, one hundred units . These numerical values pointed into a unique graph (see Figure 13).

On this graph at the horizontal axis, Munsell Hues were pointed at each " 5 Munsell Hue Steps " and Apparent Hues of Walls (resultant color shifts) were placed. At the vertical axis " Perceived Magnitudes of Spaces " for each " Apparent Hue of Walls " were shown. For these points the regression line was determined by the following equation : $y = 0.6054 + 89.7157$. The correlation coefficient ($r = 0.932$) was very high.

This linear relationship was acceptable, but only between certain hues. It was seen that there was a deficiency at the BP, P and RP region. At the same time, it was necessary to obtain a non-linear relationship (a regression curve) because the real places of the Munsell Hues were on a circle and after a 2π period, the regression curve had to pass from the same Y value. The Y values of the red under daylight fluorescent tubes (10 RP) were replaced after 2π period. Then different equations were tested and the following equation gave the most satisfactory regression curve :

$$Y = 103 + 8 \sin \frac{x - 23}{20}$$

The correlation coefficient was less than some others (r = 0.918), but this regression curve passed periodically from the necessary points (see Figure 14).

According to this curve, between 10 R and 5 YR, the " perceived magnitude of space " had a minimum value. It increased passing through YR, Y, GY, G, BG and reaches a maximum between 2.5 B and 10 B. decreases towards PB, P, RP to reach a minimum between lo R and 5 YR.

The three dimensional demonstration of this regression curve was shown on the Munsell Hue Circle. This figure is the summary of the first group results (see Figure 15).

(3.2) Second Group Analysis.

In the second group analysis, the relationships between subjects ' color preferences and estimations for the perceived magnitudes of spaces were taken. The preferences, frequencies and preferencies x frequencies are shown in the following table.

Preferences	Frequencies				Preferences x Frequencies			
	R	Y	G	B	R	Y	G	B
1. Perf.	4	5	13	20	4	5	13	20
2. Perf.	6	10	13	13	12	20	26	26
3. Perf.	8	17	10	7	24	51	30	21
4. Perf.	24	10	6	2	96	40	24	8
	42	42	42	42	136	116	93	75
Rank of Preference					4	3	2	1

This frequency distribution was treated by X^2 (chi-square) significance test for each color. Results were as follows :

- For blue ($p < 0.001$), yellow ($p < 0.02$) and red($p < 0.001$), the frequency distributions were significant.
- For green ($p > 0.30$) the frequency distributions were

insignificant, but this color had to take place between first and third choices.

After these analyses, the evaluations of the subjects who preferred blue, green as first and yellow, red as fourth were taken. The frequency distributions were treated by X^2 (chi-square) significance test for each color and each light source variable. The results were, briefly, as follows:

- The subjects who preferred blue as first choice estimated the perceived magnitude of space on the blue-walled room bigger than the other rooms.
- The subjects who preferred red as the fourth choice estimated the perceived magnitude of space on the red-walled room smaller than the other rooms.
- The subjects who preferred green as the first choice estimated the perceived magnitude of space on the green-walled room bigger than the red, yellow and blue-walled rooms under daylight fluorescent light sources, and bigger than red-walled room under tungsten filament lamps. There was no significance when green room was compared with blue and yellow rooms under tungsten filament lamps.
- The subjects who preferred yellow as the fourth choice estimated the perceived magnitude of space on the yellow-walled room smaller than blue and green-walled rooms, but there was no significance ($p > 0.10$) under each light source variable and smaller than the red-walled room under daylight fluorescent light sources, but significance was doubtful ($p = 0.10$). They estimated the yellow-walled room bigger than the red-walled room under tungsten filament lamps ($p < 0.02$).

The last two results showed that when hue effect was dominant due to light sources, there was no significance between color preference and estimation the perceived magnitude of space.

(3.3) Third Group Results.

The Difference Evaluation Lists obtained from the tests were separated for the two groups of subjects to determine whether architectural education gives some preconceptions of the evaluation of space under the color and light source variables. The data treated by Fisher's "t" test for the differences in means of estimations between two groups of subjects (architects and non-architects).

It was found that differences on the perceived magnitude estimations of space between architects and non-architects were not significant.

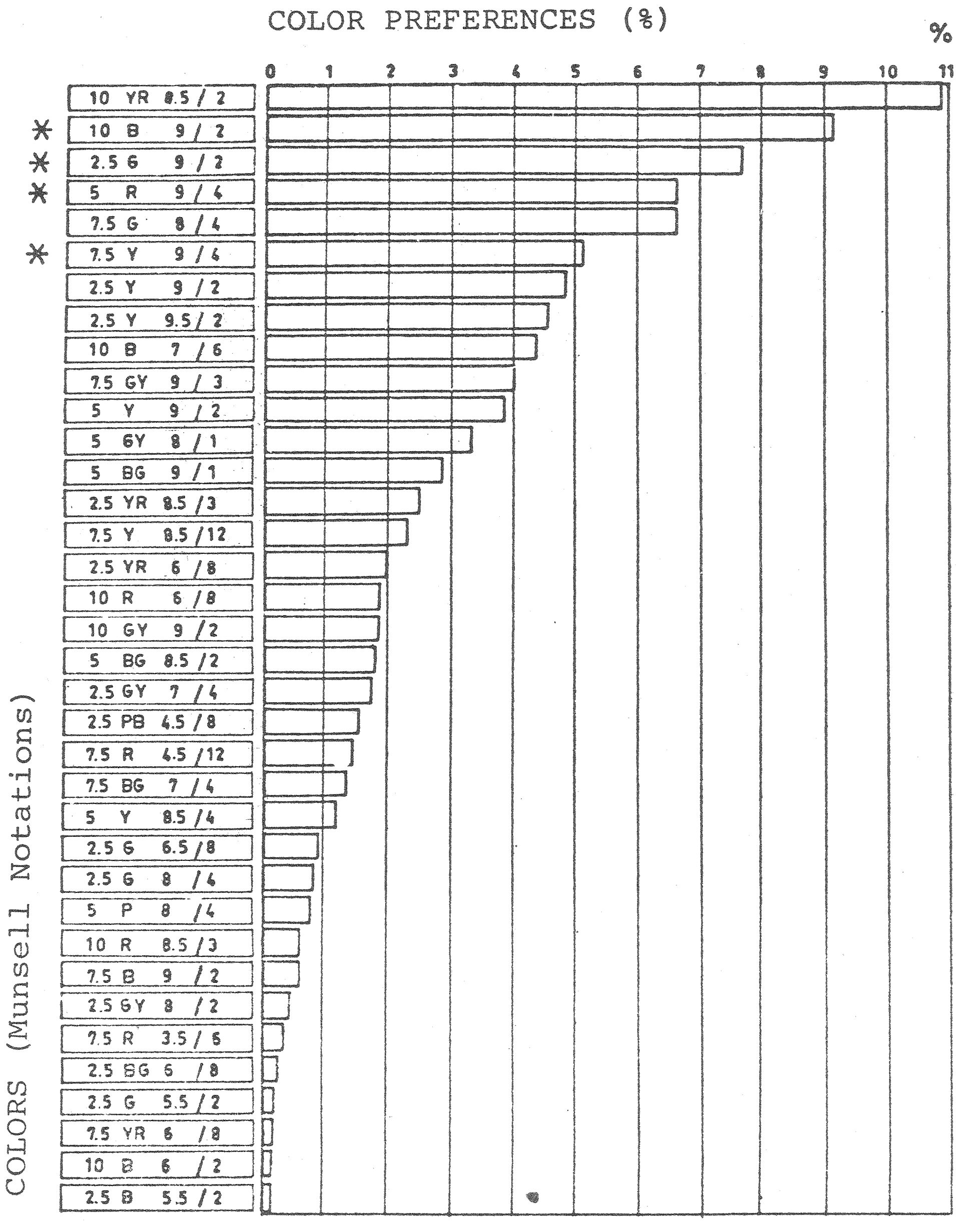


FIGURE 1. User's Color Preferences for the Interior Walls of the Buildings

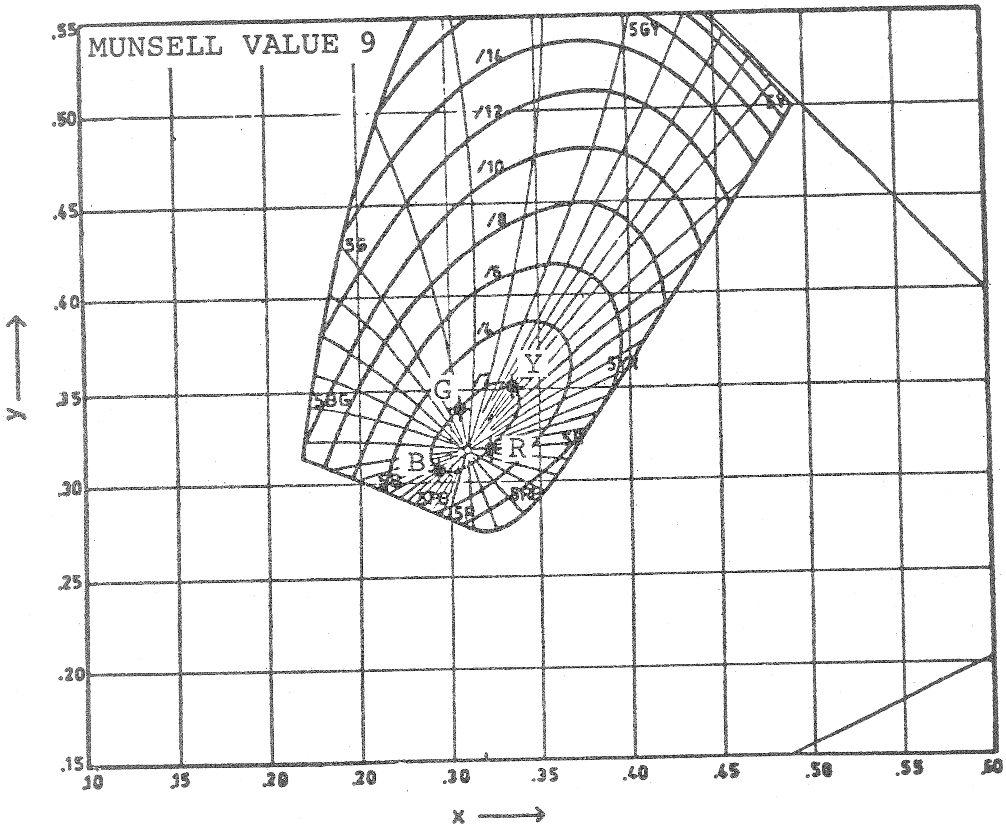
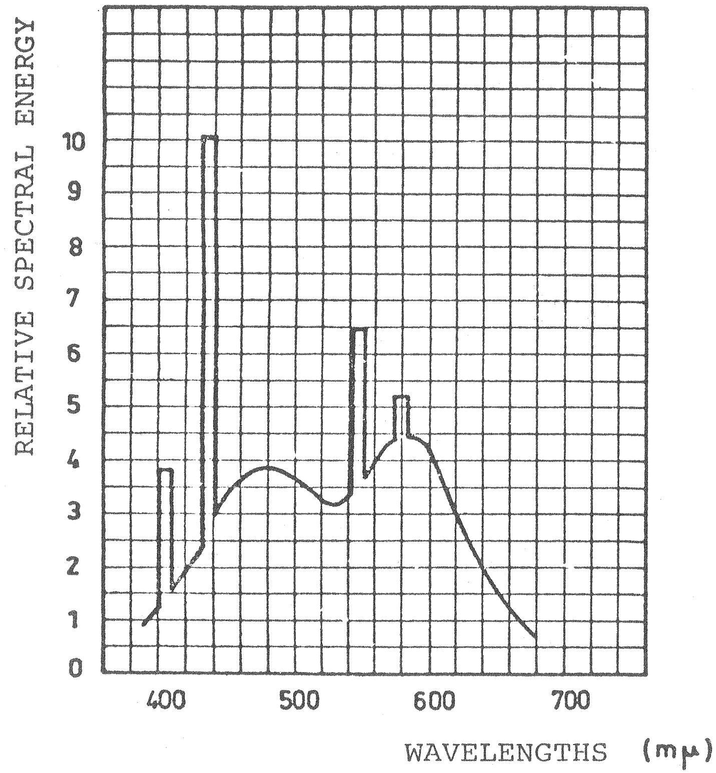


FIGURE 2. HUE VARIABLES ON THE WALL SURFACES
(The colors are given with theirs Munsell Notations and coordinates on CIE Chromaticity Diagram)

B: Blue	G: Green	Y: Yellow	R: Red
10 B 9/2	2.5 G 9/2	7.5 Y 9/2	5 R 9/2
x = 0.294 y = 0.306	x = 0.306 y = 0.340	x = 0.336 y = 0.352	x = 0.324 y = 0.318



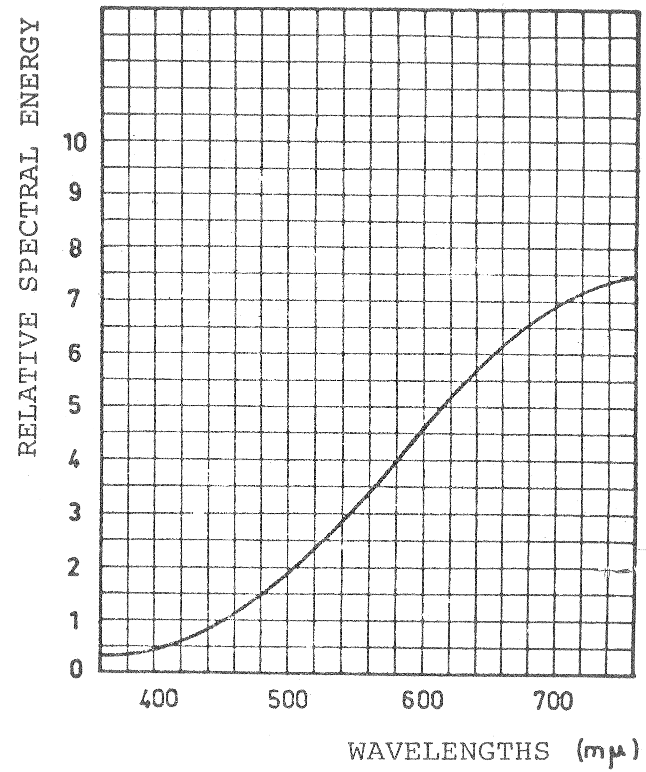


FIGURE 3

SPECTRAL ENERGY DISTRIBUTION OF THE "DAYLIGHT" FLUORESCENT TUBE

(20 W Correlated Color Temperature 6500°K)

SPECTRAL ENERGY DISTRIBUTION OF THE TUNSTEN FILAMENT LAMP

(60 W , Color Temperature 2790°K)

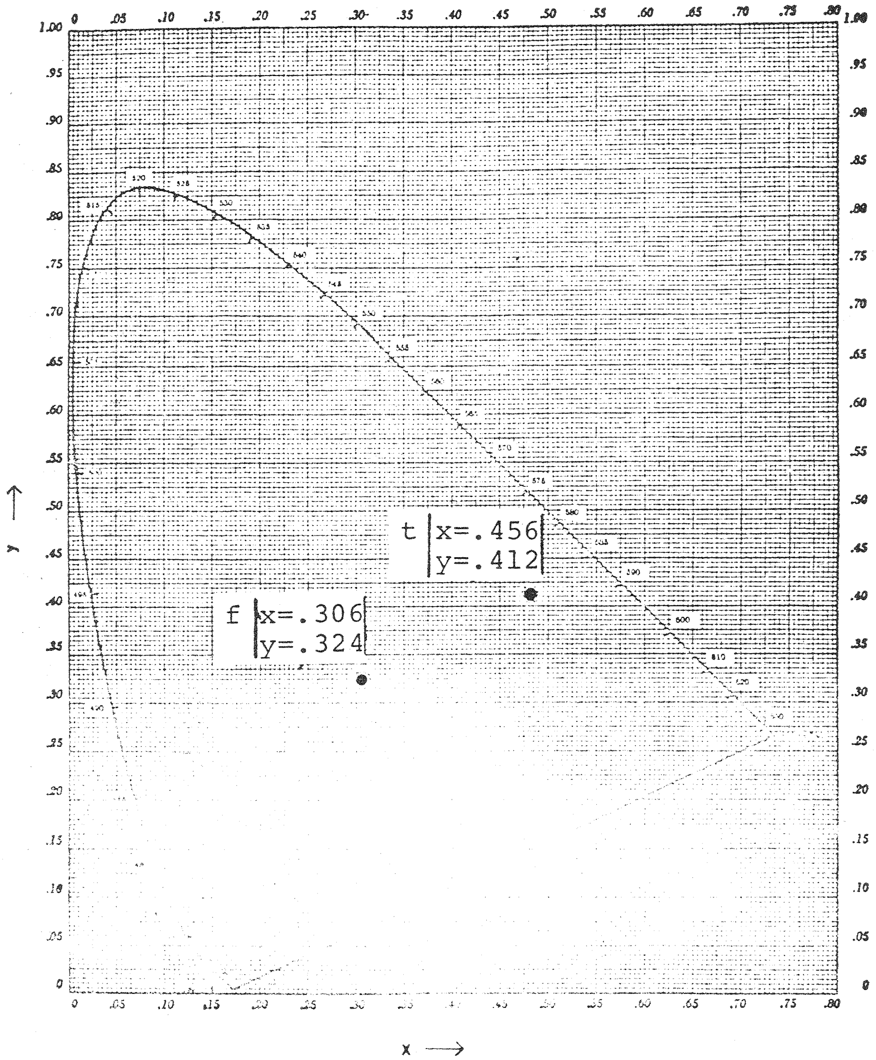


FIGURE 4 . CHROMATICITY POINTS OF THE TWO LIGHT SOURCES ON THE CIE CHROMATICITY DIAGRAM

f:Daylight FLUORESCENT Tube
t:TUNGSTEN Filament Lamp

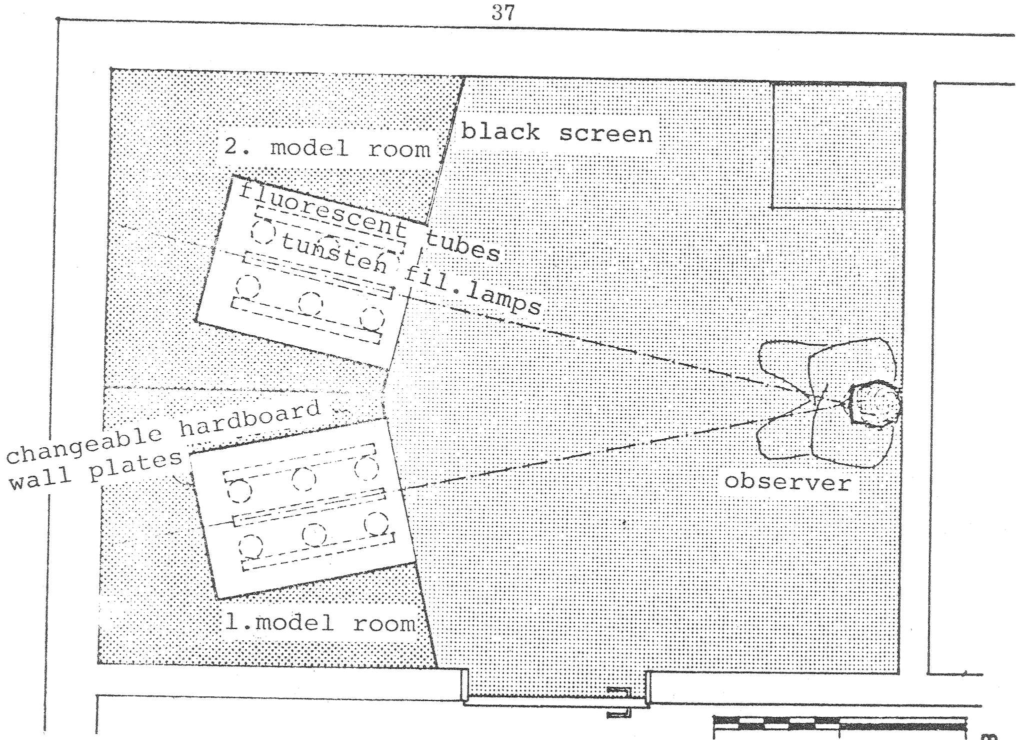


FIGURE 5 .EXPERIMENT ROOM, PLAN

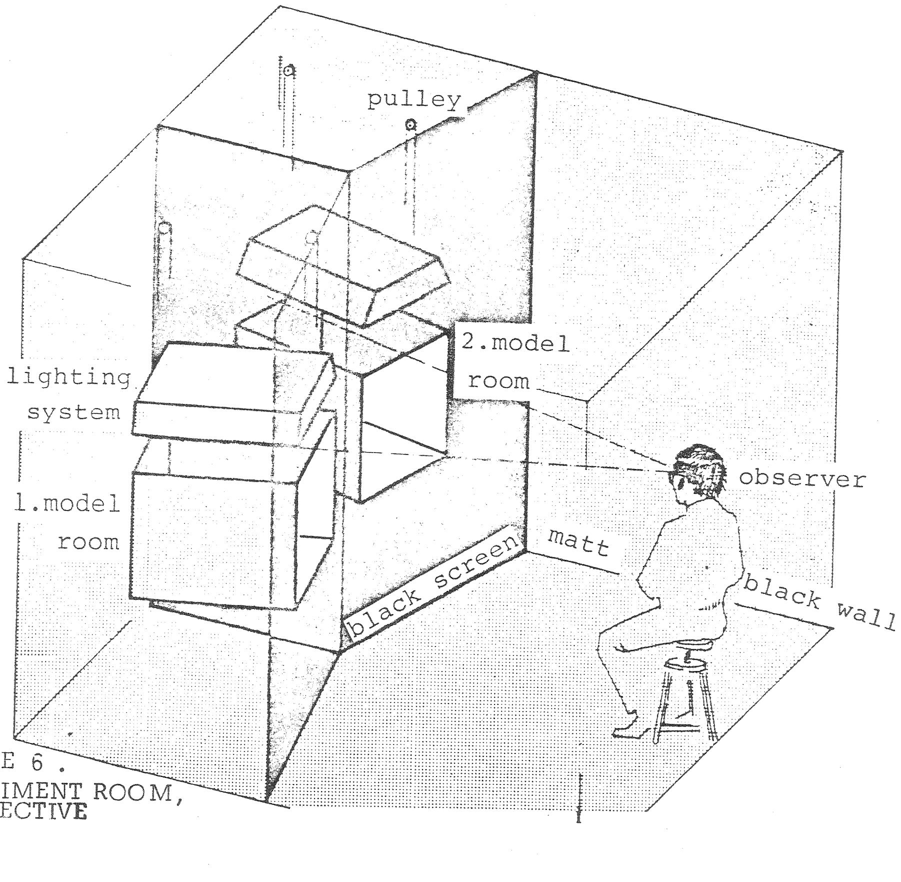


FIGURE 6 .
EXPERIMENT ROOM,
PERSPECTIVE

Table 1: Color Shifts of the Wall Surfaces of Model Rooms due to Multiple Interreflections under Tungsten Filament and Daylight Fluorescent Light Sources (Coordinates on the CIE Chromaticity Diagram)

Under Natural Daylight	Resultant Color Shifts			
	Under Tungs. Fil. S.		Under Dayl. Flu. S.	
	Floor N. Grey	Floor Colored	Floor N. Grey	Floor Colored
RED	R_t	R'_t	R_f	R'_f
5 R 9/2 x = .324 y = .318	10 R 9/4 x = .360 y = .336	10 R 8/4 x = .363 y = .337	10 RP 9/1 x = .316 y = .316	7.5 RP 9/2 x = .319 y = .316
YELLOW	Y_t	Y'_t	Y_f	Y'_f
7.5 Y 9/2 x = .336 y = .352	5 Y 9/5 x = .374 y = .393	5 Y 9/6 x = .387 y = .406	2.5 GY 9/2 x = .334 y = .353	2.5 GY 9/4 x = .350 y = .386
GREEN	G_t	G'_t	G_f	G'_f
2.5 G 9/2 x = .306 y = .340	2.5 GY 9/4 x = .350 y = .386	2.5 GY 9/6 x = .368 y = .420	7.5 G 9/2 x = .299 y = .332	10 G 9/2 x = .296 y = .330
BLUE	B_t	B'_t	B_f	B'_f
10 B 9/2 x = .294 y = .306	10 G 9/1 x = .302 y = .324	7.5 G 9/2 x = .299 y = .332	5 B 9/4 x = .266 y = .299	5 B 8/5 x = .254 y = .294

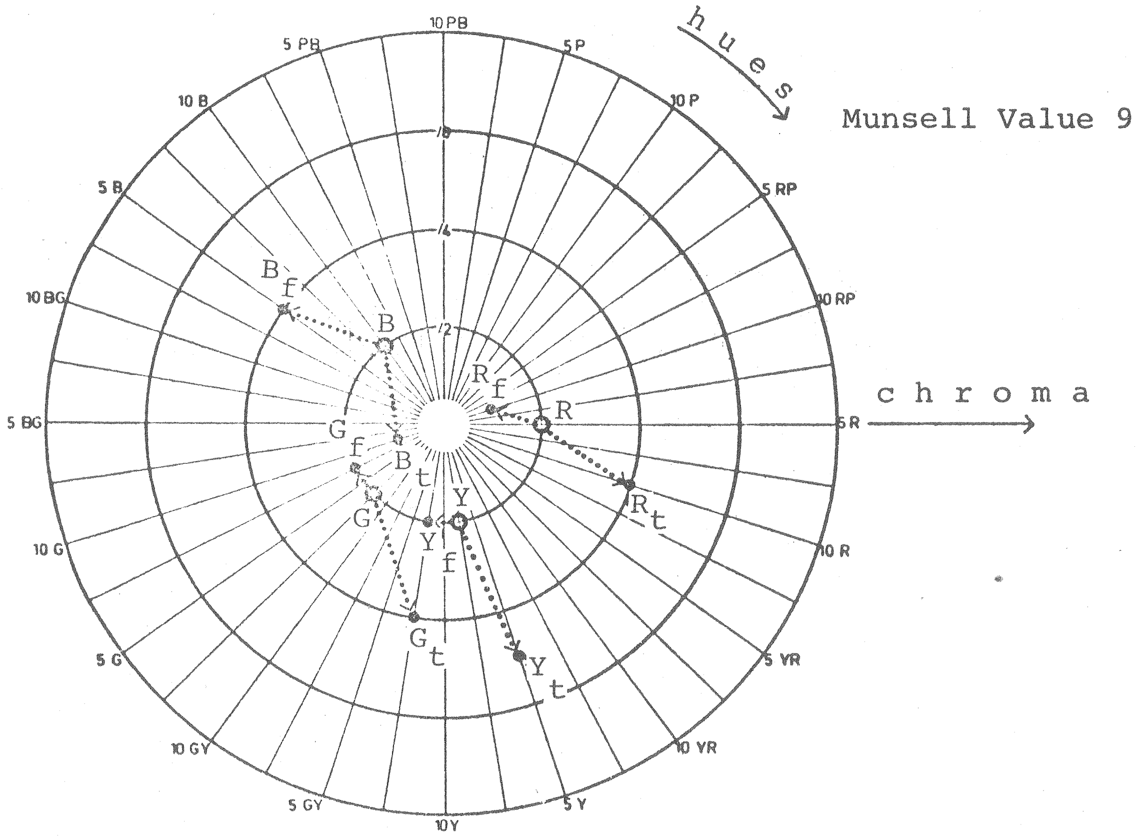


FIGURE 7 . COLOR SHIFTS ON THE WALL SURFACES DUE TO MULTIPLE INTERREFLECTIONS UNDER TUNGSTEN FILAMENT AND DAYLIGHT FLUORESCENT LIGHT SOURCES(floor:neutral grey,Munsell V. 7)

R,Y,G,B :Four choosen colors in daylight
R_f,Y_f,G_f,B_f:Four choosen colors under "daylight fluorescent" light sources
R_t,Y_t,G_t,B_t:Four choosen colors under "tungsten filament" light sources

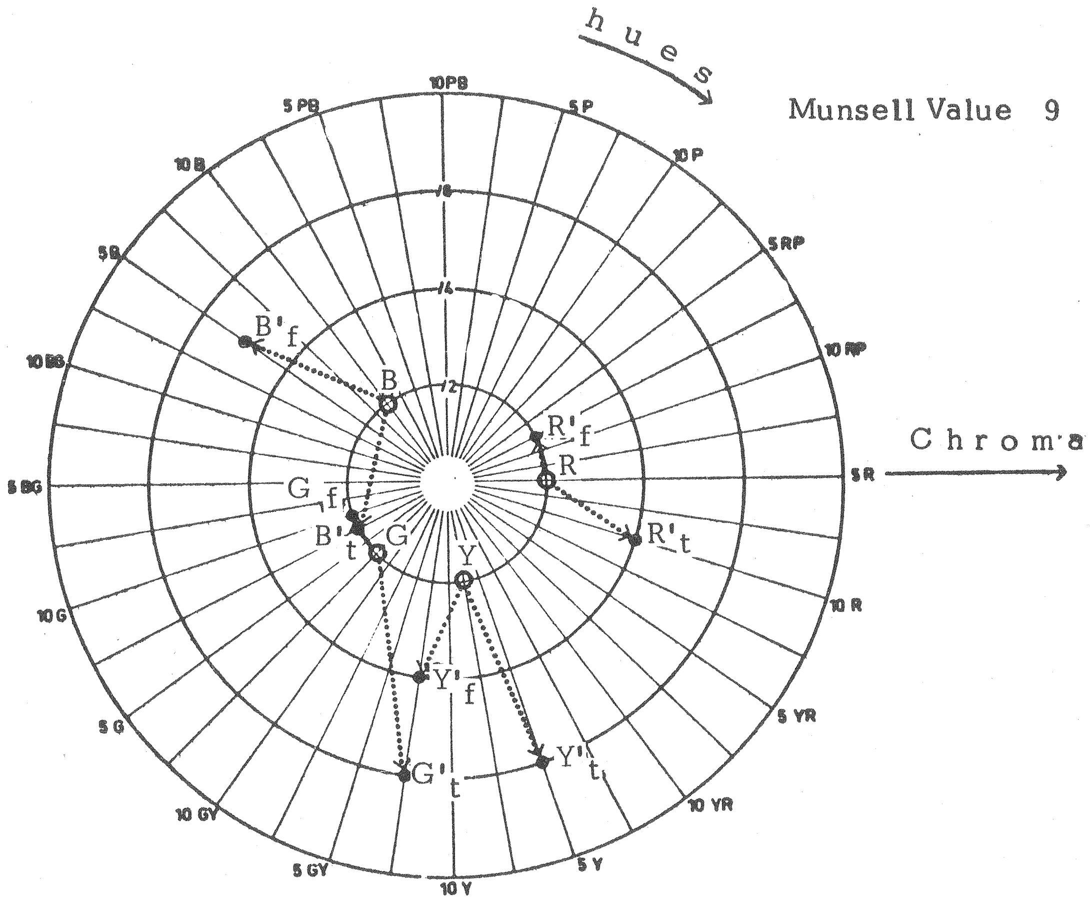


FIGURE 8 COLOR SHIFTS ON THE WALL SURFACES DUE TO MULTIPLE INTERREFLECTIONS UNDER TUNGSTEN FILAMENT AND DAYLIGHT FLUORESCENT LIGHT SOURCES(floor:at the same color with the walls)

Table 2 .DIFFERENCE EVALUATION LIST FOR THE FOURTH GROUP PAIRED COMPARISONS
The walls are at the same color in both of the model rooms, and one of the model rooms is under "tungsten filament lamps", the other one under "daylight fluorescent tubes"

SUBJECTS	RED Walls			YELLOW Walls			GREEN Walls			BLUE Walls		
	und. T.F. lamp BIG. %	EQU.	und. D.F. tube BIG. %	und. T.F. lamp BIG. %	EQU.	und. D.F. tube BIG. %	und. T.F. lamp BIG. %	EQU.	und. D.F. tube BIG. %	und. T.F. lamp BIG. %	EQU.	und. D.F. tube BIG. %
1			5			5			5	10		
2			5			2			2		0	
3			1			1			1			1
4			5			5			5			10
5			5			2			5			5
6			3	4					4			3
7	5					5	5			10		
8			5			5			5			5
9			2			1	2			2		
10			5			2			3			5
11			8			5			10			10
12			5		0				5			5
13		0		2				0				2
14			1			3			2			4
15			5			6			5			1
16			4	2				0				3
17		0			0				2		0	
18	3					2			5			5
19	2					1			3		0	
20			5			2			5	5		
21			2	2					5	3		
22		0				1		0				1
23			2			2			4			2
24	5					1	1			1		
25	2			1			1			1		
26	5			4			2					2
27			5			2			6			3
28			2			5			5			5
29			6			3			3	2		
30			1	2					2			3
31		0				2	5				0	
32			3			4			3			5
33	2			1				0			0	
34			2		0			0				1
35		0				1		0				5
36	1			3			3				0	
37			2		0				2			2
38			1			1			1			1
39			3			2			2			5
40		0				3		0		5		
41			3			5			5			4
42			5			5			10			5
Sum.	25		101	21		84	19		115	39		103
Freq. D.	8	6	28	9	4	29	7	7	28	9	6	27
Mean	3.1		3.6	2.3		2.9	2.7		4.1	4.3		3.8
σ	1.64		1.83	1.11		1.67	1.86		2.21	3.53		2.37

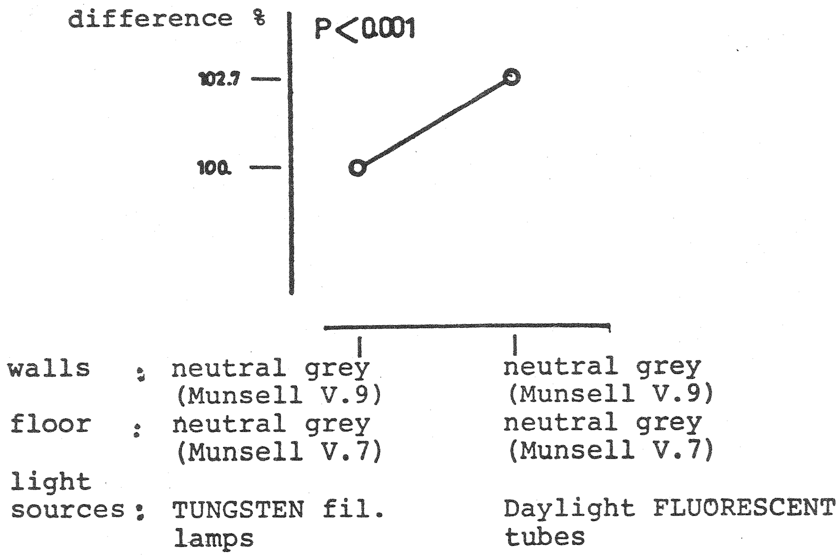


FIGURE 9. DIFFERENCES BETVEEN "PERCEIVED MAGNITUDE OF SPACES"

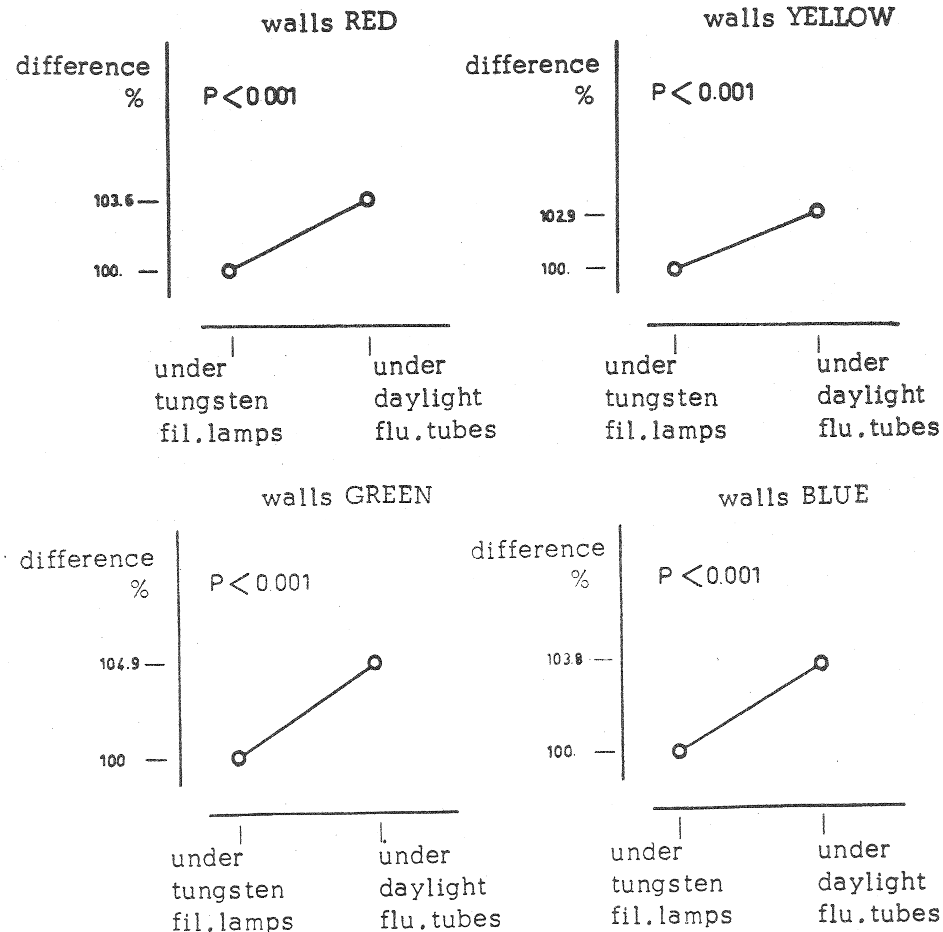


FIGURE 10. DIFFERENCES BETWEEN PERCEIVED MAGNITUDES OF SPACES

floor : neutral grey (Munsell V.7)

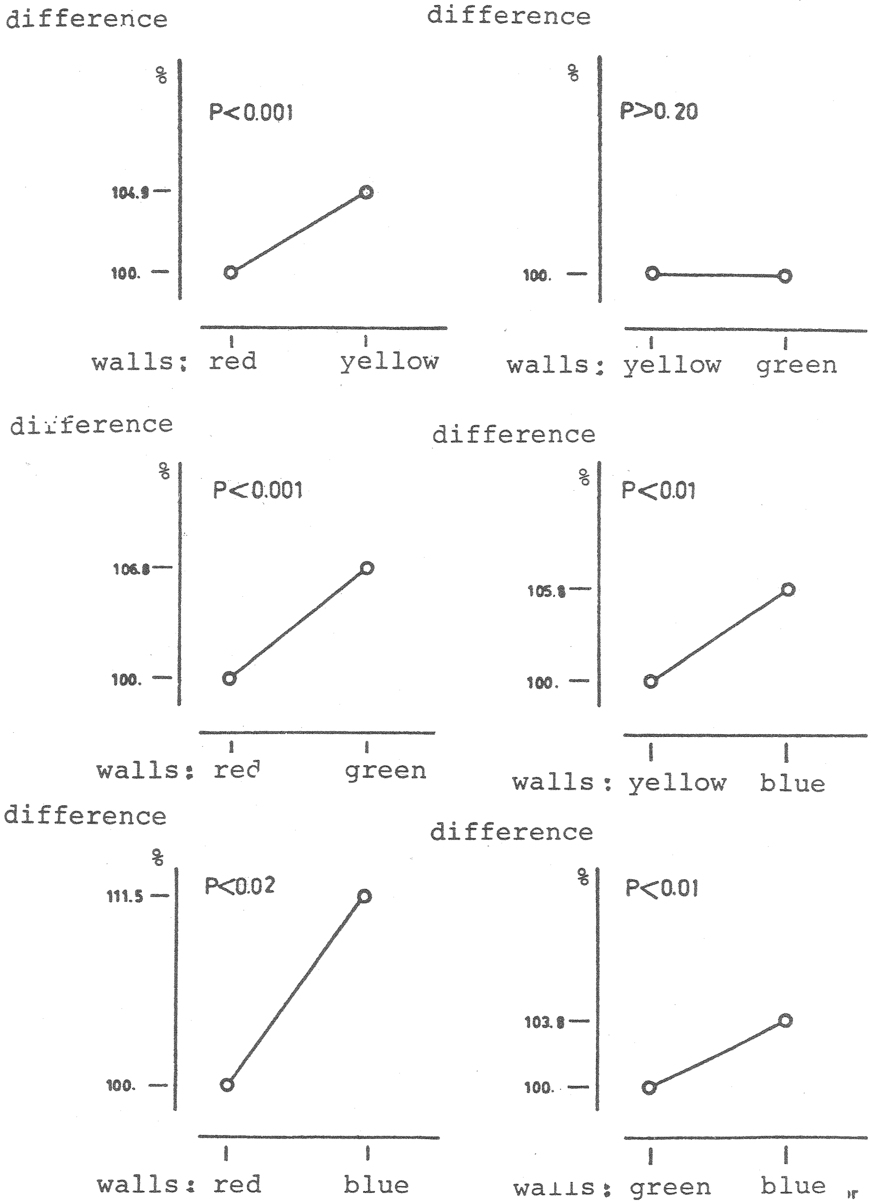


FIGURE 11 DIFFERENCES BETWEEN "PERCEIVED MAGNITUDES OF SPACES"

light sources: TUNGSTEN filament lamps for two model rooms
floor : neutral grey (Munsell V.7)

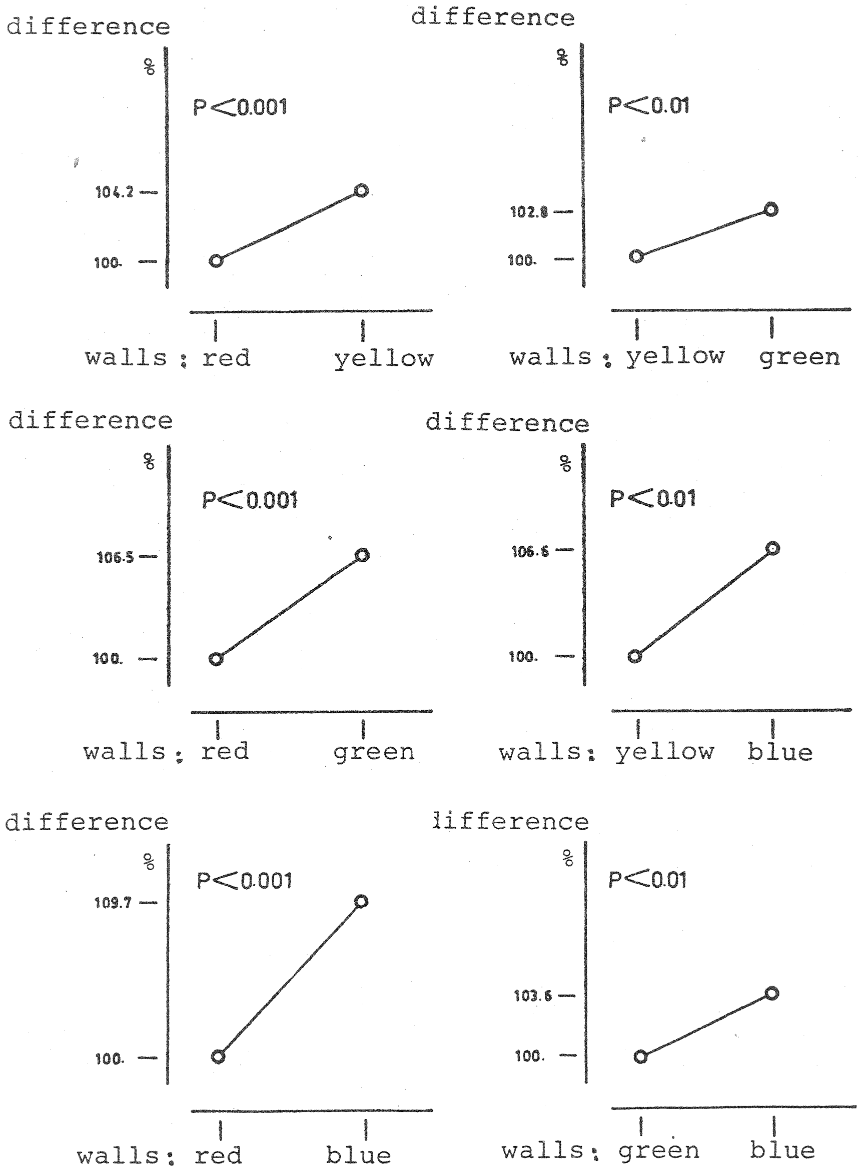


FIGURE 12 . DIFFERENCES BETWEEN "PERCEIVED MAGNITUDE OF SPACES"

light sources: daylight FLUORESCENT tubes for two model rooms
floor : neutral grey (Munsell V.7)

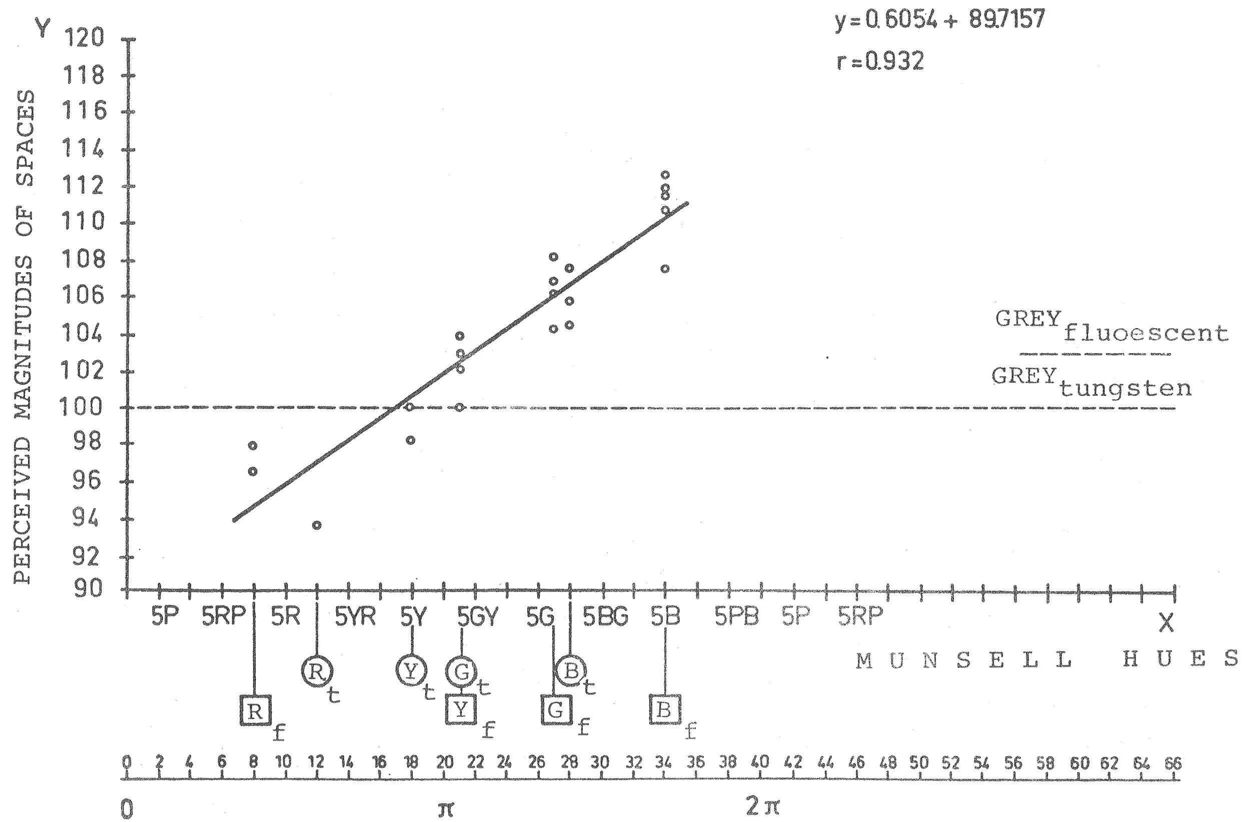


FIGURE 13 . The Perceived Magnitude of Spaces Depending on "Apparent Hues" of Walls which are Results of the Color Shifts under the Two Type Light Sources and the Regression Line

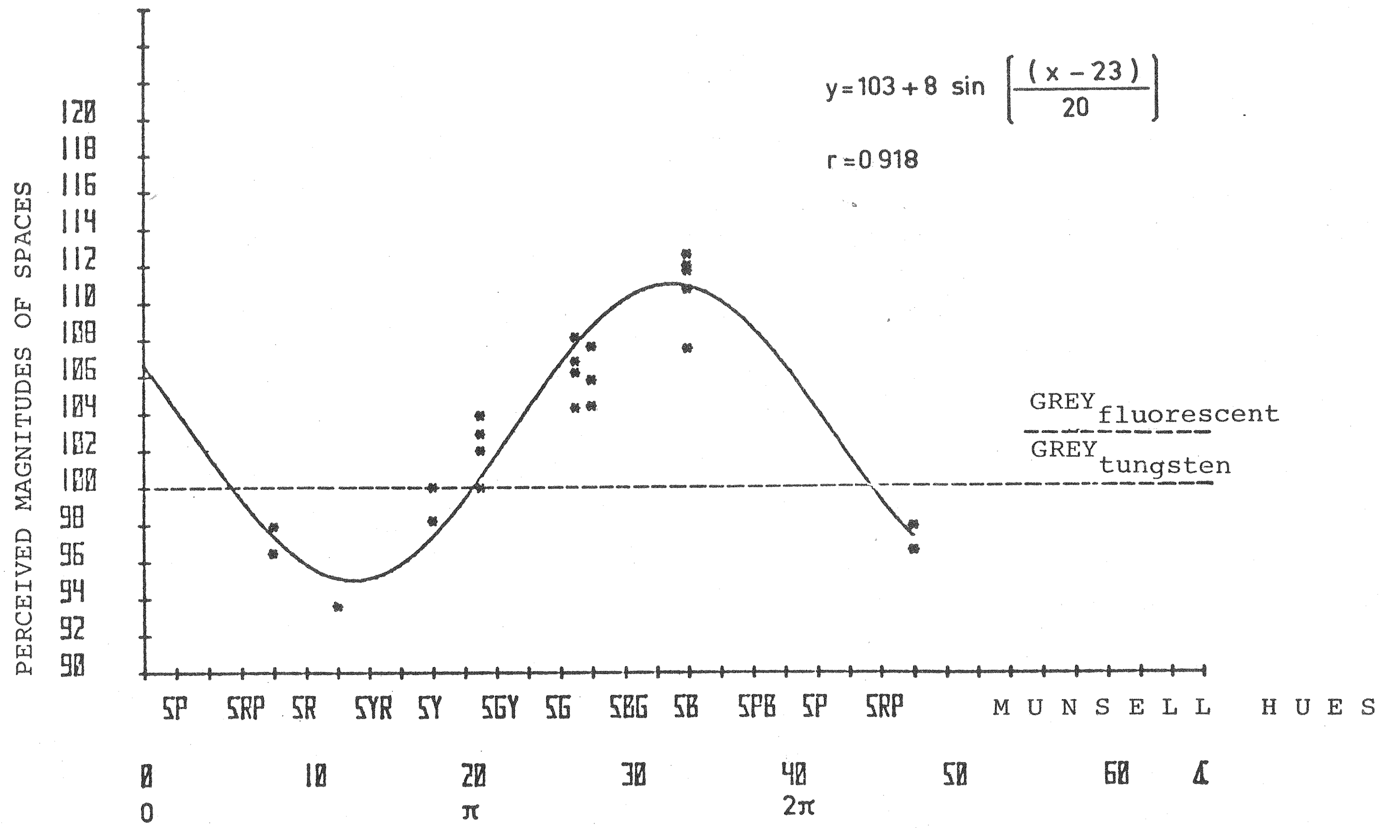


FIGURE 14 . The Perceived Magnitude of Spaces Depending on "Apparent Hues" of Walls which are Results of the Color Shifts under the Two Type Light Sources and the Regression Curve

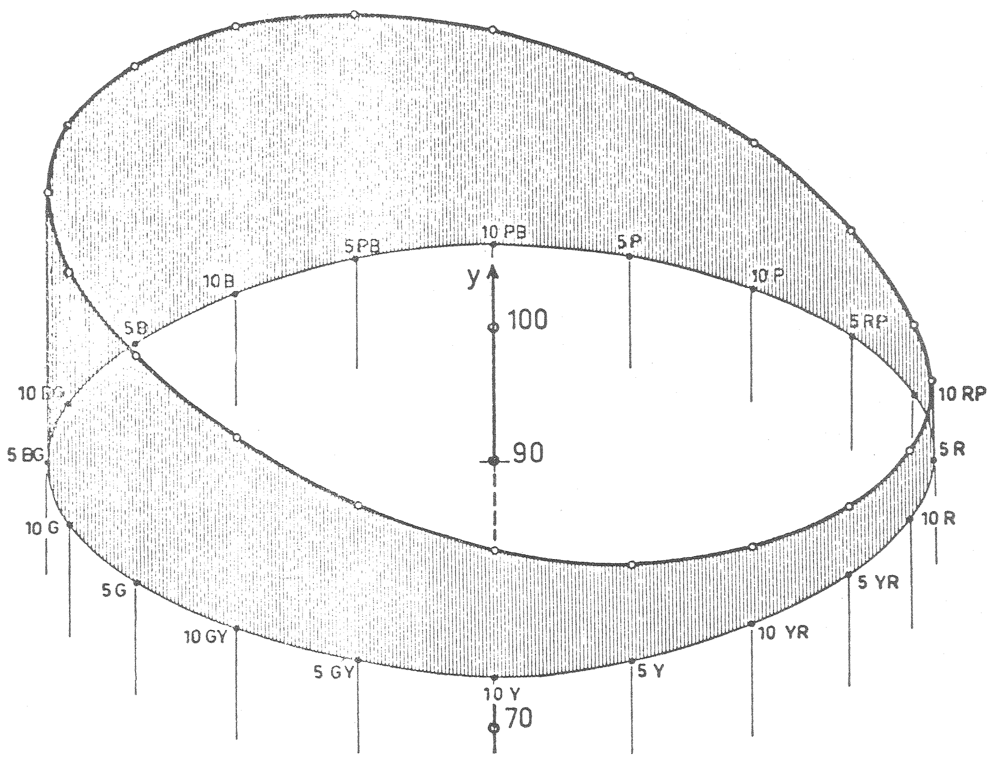


FIGURE 15 . The Three Dimensional Demonstration of the Regression Curve $y = 103 + \sin \frac{(x - 23)}{20}$ on the Munsell Hue Circle

A METHOD TO SOLVE NOISE CONTROL AND SPEECH PRIVACY PROBLEMS, FOR USE IN ARCHITECTURAL PROCEDURE

Dr. NURTEN AKSUGÜR

As a result of high population density and close living conditions, speech privacy has become a problem of modern times. In this study the problem is investigated for " open-window " condition. A graphical method which has been developed is proposed for use in design procedures. The study consists of four parts.

PART 1

In the first part speech privacy is defined and architectural conditions under which the problem would arise is discussed.

The problem is analysed from the view points of those aspects related to the source, the medium and the receiver.

These related aspects are :

Source : Speech voice, its spectrum and level

Medium : Background noise, source room absorbtion, receiver room absorbtion, transmission loss of a common partition, excess attenuation of sound level during its passage through the window

Receiver : Hearing limits of human ear, speech inteligibility.

A survey of the of the literature and the works of other investigators which follows led to the discovery of that previous studies consider the problems of speech privacy and the radiation of sound at open window condition separately but not together. As a result it is concluded that :

> Sound radiation at open window condition and its implication on the problem of speech privacy should be investigated as a whole. When this is done, a method which can provide some assistance to architects in desing procedures can be developed.

- Such a method would require experimental investigation of the directivity pattern for sound coming out of an open window, (i. e. variation at the level of sound with the direction of radiation).

- Such a method would also require a similar investigation for sound coming in from an open window.

PART 2

This part deals with experimental investigation of the directivity patterns of sounds coming in and out of an open. window. It is supposed that the level of sound coming out an open window wouldbe affected by

- The window ratio (width/height)

- The frenquency of the sound

- The direction of radiation of the sound.

A group of tests is made with these considerations. FIG : 1 The results are plotted to form the directivity pattern. It is found that the directivity pattern agrees with the $\cos^n \theta$ law only for window ratios of 1/1 and 1/2 . However deviations occur for other window ratios such as 1/4 and 4/1 . A similar experimental investigation is carried out for sound coming in from an open window. FIG : 2 Here it is supposed that the sound level would be affected by

- The window ratio

- The frequency of the sound

- The relative positions of the source and receiver rooms.

The results of these second series of tests are processed with the aid of a computer and expressed in the form of a graph.

PART 3

In this part the method developed for use in architectural design procedures is explained. Using this method, an architect can create an environment suitable for speech privacy by choosing the right window proportion, relative position of and the distances between the windows. The method consists of four steps :

In step one, the level of the incident sound of the source determined from the graphs provided. In these graphs the level of speech voice is plotted against the speech voice frequency. These graphs are called " the speech voice spectrum ". These graphs are plotted for the three states of human voice :

1) Loud voice
2) Raised voice
3) Normal voice

The architects have to choose the graph which reflects the conditions in the source room best.

In the second step the level of the incident sound at the receiver room is determined. Changes in the level of sound due to its passage through the open windows and the common wall are taken into consideration. The total variation in the level of the incident sound reaching the receiver room through open windows ($\Sigma \Delta L_D$) is calculated as :

$$\Sigma \Delta L_D = \Delta LSA_1 + \Delta Ll + \Delta LSa_1 + \Delta LSa_2 + \Delta LDI + \Delta LG + \Delta LSA_2$$

where :

ΔLSA_1 : Variation due to source room absorbtion

ΔLl : " " " window distance

ΔLSa_1 : " " " source room window area

ΔLSa_2 : " " " receiver room window area

ΔLDI : " " " source room window directivity

ΔLG : " " " receiver room entrance "

ΔLSA_2 : " " " receiver room absorbtion.

These amounts of variation are found from the graphs provided.

The total variations in the level of the incident sound reaching the receiver room through the common partition ($\Sigma \Delta L_B$) is calculated as :

$$\Sigma \Delta L_B = \Delta LSA_1 + \Delta L \frac{SB}{SA_2} + \Delta L_{TL}$$

where :

ΔLSA_1 : Variation due to source room absorbtion

$\Delta L \frac{SB}{SA_2}$: " " " the joint effect of receiver room absorbtion and the common wall

ΔL_{TL} : Transmission loss of common partition.

For each case (Open window and common wall) calculated variations in the level are added to the speech voice spectrum. In this way two modified spectrums are formed.

In step three logarithmic sums of these two spectrums are taken to find the total level of speech voice reaching the receiver room. The level of the background noise is substracted from this and the amount left is called " Speech level contribute to intelligibility ".

In step four the intelligibility of this sound in checked. For this purpose the graph found in step three is compared with the graph showing the variation of the degree of intelligibility of human voice with its frequency.

PART 4

In this last part experimental and theoretical investigations covered in this work are listed. The possible future applications and research possibilities are discussed.

A summary of proposed graphical method is given in the flow diagram. FIG : 3

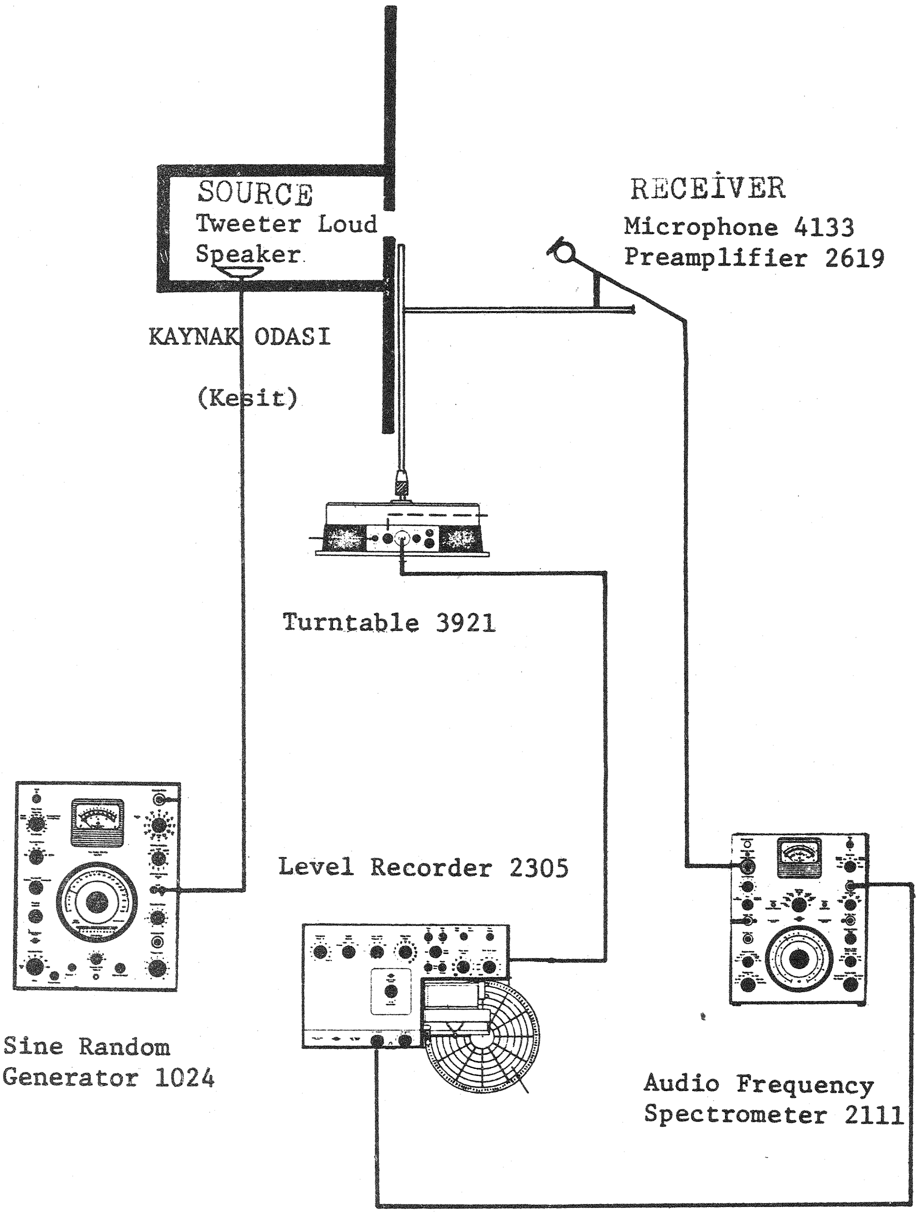


FİGURE 1
1. group of tests set up

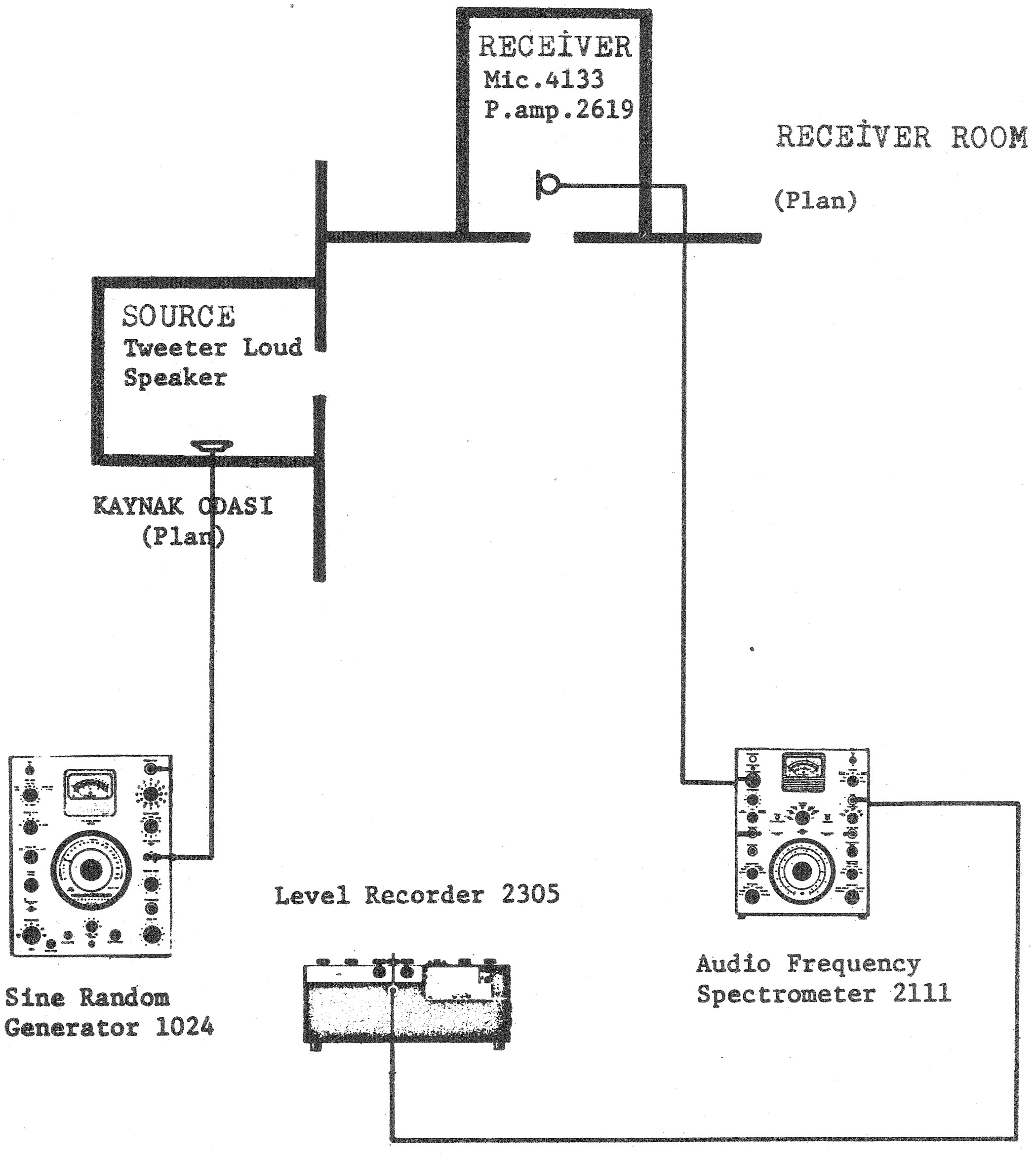
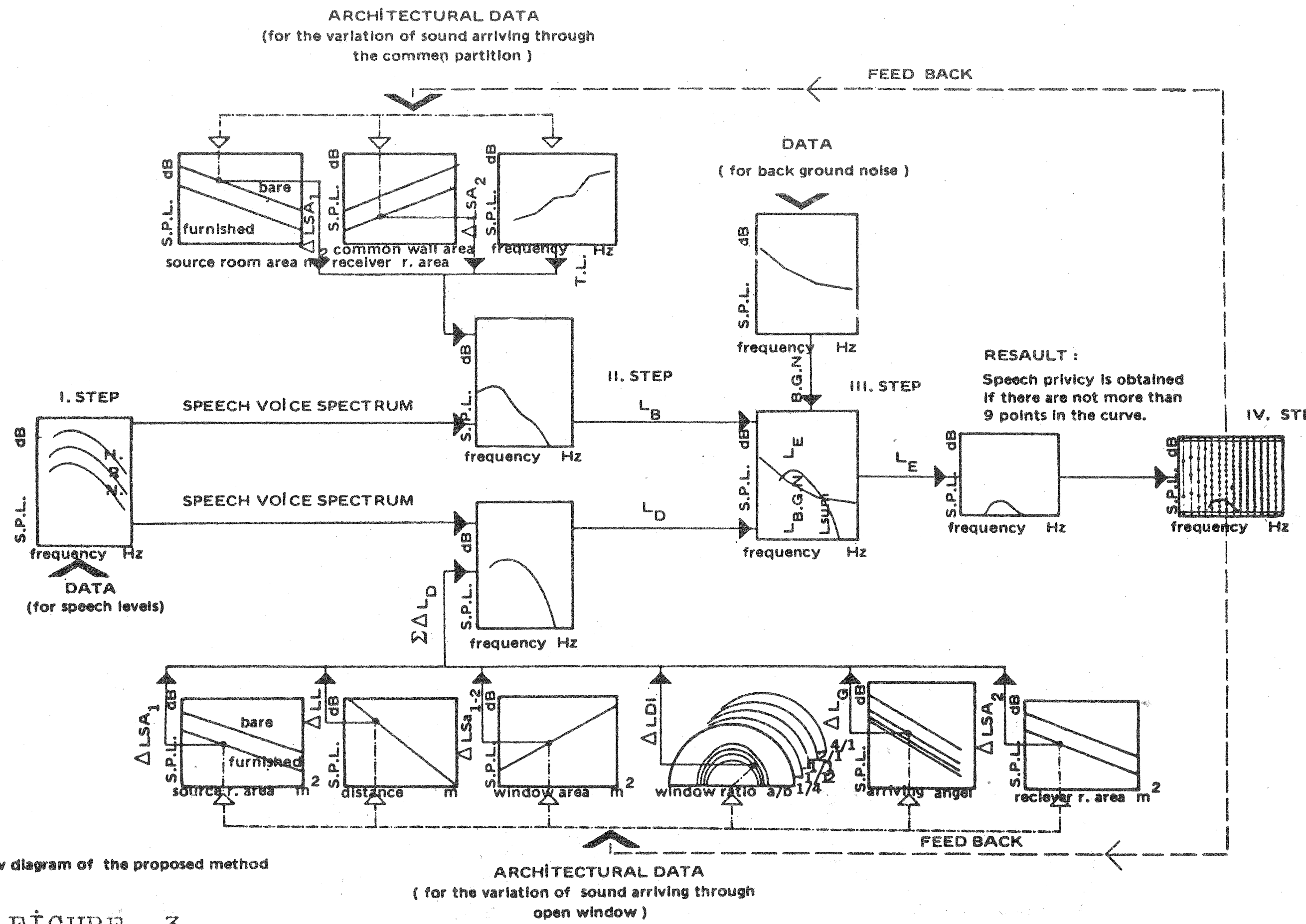


FİGURE 2

2. group of tests set up



Flow diagram of the proposed method

FİGURE 3

A METHOD TO DETERMINE SPATIAL REQUIREMENTS WITH SPECIAL EMPHASIS ON USER COMFORT

Dr. ZAFER ERTÜRK

It is suggested that the rapid development of research on the interaction of people and buildings leads to the need for careful consideration of the place of new methods and techniques.

The aim of this thesis is to develop a method to determine spatial requirements users.

The common problem emerging in studies concerned with the investigation of relationship between man and his environment is the concentration of the studies on the domination of man to his environment. In other words, only man's influence on his environment is taken into consideration as the subject of these. And this facilitates the procedure. However, for a sound understanding of relationship, the realty of reciprocal interaction between man and his environment must be accepted and to apply this realty in the practical field, principles of systems approach must be tested on problems which are dealt with, within the interaction of man and his environment.

Man and his environment constitute a man-environment system due to the organic link between them. This organic link is the result of the reciprocal interaction.

In this research, environment is considered in artificial indoor environment scale and, spatial requirements from the point of view of comfort are investigated.

The objectives of this work can be summarized as :

- Determination of spatial requirements from the point of view of comfort.
- Investigation of changes in requirements over-time.

The work is constituted of an introductory part and six main parts.

In the introduction, interactions between man and his environment, concept of user requirenments, objectives of the work are discussed in length.

In the first part, motivation of the methods, which will be suggested later, are discussed and, explanations on Systems Approach, Model Concept are given according to the essence of the subject and, motivations for adapting the systems approach for man-environment problems are defined.

The designer user relationship which changed as a result of the Industrial Revolution and population growth, is pointed out as the motivation for new techniques.

System approaches can be divided into three categories as :

. Structural approach
. Cybernetic approach
. Dialectic approach

Determining the requirements emerges as a structural system approach, while investigation the changes in requirements over time emerges as cybernetic or dialectic approach.

In the second part, models of probable relationships between man and artificial indoor environment are investigated. Models of probable relationships between user 's comfort and individual physical characteristics of artificial indoor environment are discussed. Although these models describe a mechanical relationship, they may still enable the determination of requirenments, if the users groups are defined in adequate scale.

In the third part, model and field studies on spatial requirements, which were carried out previously, are evaluated from the point of view of distinction of the variables and variables which constitute user 's comfort from the spatial angle and which are related to man and to artificial indoor environment are listed.

The variables which have been in toaccountin the developed model listed as below :

. Shape of the space
. Dimentions of the space
. Total area of space
. Total activity area of space
. Total equipment area of space
. Functional area of space
. Number of user of the space
. Psyhological area coefficient
. Density of activity of space
. Density of the number of users interactions of space

Also within the spatial characteristics, such models as in second part, that is, models of relationship between other physical characteristics of space and sense of comfort, are looked for.

A method for determining spatial requirements of users is developed through models of relationship between spatial characteristics of space and sense of comfort of the users. And this method is described, discussed step by step.

In the fourth part, the way of determining changes is spatial requirements is defined through changes over-time in interaction models.

In the fifth part, the methods suggested theoretically in the third and fourth parts are applied according to the data collected through field studies on housing in Borough of Akçaabat in The Eastern Black Sea Region.

Theoretically, variables in space magnitude seem to be valid for all kinds of space units. But in such units, as a classroom, a hospital room, an hotel room, alongside with the defined variables, there will be variables related to order of activity, administration, maintenance and education system.

These variables are not included in the developed model and therefore applications in dwellings will give sounder results. And, in dwellings, only living rooms are selected as the area of application, for, there is more opportunity of gaining access into these particular spaces, during field studies.

In the last part, the result of this theoretical study and the application are discussed, suggestions for future studies are put forward.

It is endeavoured to define the contributions of such techniques in both theory and application and to evaluate these from the point of view of changing problems of the design.

THE SUGGESTED METHOD :

We can summarize the method for developing indexes to be used in practice as follows :

- Defining each user groups by determining in detail the user specifications.
- Selecting a sampling group for each of the user groups and the characteristics of the space where this sampling group lies.

That is, determining :

- Dimensions of space (a, b, h)
- Dimensions of the equipment used in the space
- The functional area in the space

- Determining, on a comfort value table, the responses of the considered sampling groups of their specified spaces.
- Determining, within two dimensional systems, the relationships between related dimesional variables of space and comfort, through regression analysis.
- Specifying activities in the space which design is being considered.
- Determining equipment to be used for the activities to be performed.
- Calculation of total areas of activity and equipment.
- Determining the functional area, through relationship models and by making use of relationship between total activity area and functional area, and controlling the results through relationship between total equipment area and functional area.
- Determining the total area through relationship models and by making use of relationship between functional area and total area, and controlling the results through relationship between total area and number of user relations.

THE SUGGESTED METHOD FOR DETERMINING THE DIFFERENTIATION SHOWN WITHIN TIME DIMENSION BY SPATIAL REQUIREMENTS:

The changes in relationship models were studied in determining the differentiation shown within time dimension by spatial requirements.

Two ways are suggested here :
- Studying the selected sampling group at given time intervals and determining the eventual changes in the relationship models during these intervals.
- Determining the effect of time on relationship models by studying two sample groups which show differentiation from the time dimension angle.

The second way was tried in this work for the first one caused loss of time in research.
- The changes in requirements within time can be distinguished by starting from differences between relationship models obtained from the two sampling groups and by following the above listed steps.

RESULTS AND PROPOSALS FOR FURTHER RESEARCH

Suggestions produced at the and of this work are grouped under headings :

1. Suggestions related to Architectural Education with spacial emphasis on Design Education
2. Fields of research undealt with related to the problem considered in this work.

The scarcity of experimental work in such scale in our Country causes a continous production of equipments which do not comply with our standards. Bearing in mind the geographical conditions of our Country, extending field studies by setting-up mobile laboratories and establishing, in the meantime, closer relationship with users can be considered.

A METHOD FOR DETERMINING THE AREA OF INFLUENCES OF CİTİES IN THE TRABZON SUB-REGION OF EASTERN BLACK SEA: FREQUANTATION APPOACH.

Dr. ŞİNASİ AYDEMİR

I. I

The aim of this study is to develop a method to delimit the area of influences of cities in the Trabzon Sub-Region of Eastern Black Sea in Turkey and to search for possibilities of redefining the exsisting boundaries of this region.

The region has been mainly a geographical concept, concerned mostly with physical space. While geography is concerned with partition and limitation of the space, it can also be defined as 'an area within which the combination of environmental and demegraphic factors have created a homogenity of social structure.

Regions can be defined in terms of their areal associations such as uniform regions, or in terms of the functions performed in them. In this sense, a region is an area where people are bound together by mutual dependencies arising from common interests.

Geographical definitions of regions are more static, but definitions in terms of human activities such as flows of goods, information, etc., are more realistic and flexible and this give an opportunity for development. For this reason, we tried to redefine the region using human interaction or frequency of visits made different purposes. That delimits an accessible, reasonably large area termed as region. Then functional areas or regions are defined.

When one speaks of human interaction and density of frequency of visits among settlements, one also speaks of order among them such as rank-size or rank in terms of centrality in a given region. This sort of thinking brings in the problems of demarcation of boundaries among settlements or regions which may differ from legally defined. boundaries. Functional classification of settlements and the hierarchy in the region that have been investigated in this study show the functional classification and specialization in the region in providing central functions. This gives a clear picture of the region under investigation

The methods of determining the regions differ with the aim and and there are various techniques to deal with this problem. What is -

intended here is to develop an interaction oriented frequentation model to show how people have acces to urban services with least, efford in a behavioural sense.

In this study an attempt was made to determine the area of influences of cities in the Trabzon Sub-Region. Ofcourse, there are many aspects of this study which have to be dealt with in sequence. Other aspects related related to this study, such as population growth and accessibility, are studied.

The concept of region and regionalism and the techniques for definition of regional boundaries critized in terms of their applicability and the data used. As a definition technique for regions, area of influences and the recent studies related to this are carefully reviewed. Theorethical and empirical studies are compared, such as classical central place studies and urban rank-size, gravity type models and catchment areas of centres. As an empirical study, functional classification of urban centres are briefly reviewed with qualiative and methods to show the urban hierarchy.

1.2

Studies in Turkey on regionalism and definition of regions are discussed in the light of general conclusions which were drawn from earlier studies. The need for a clear identification of functional for (nodal) regions is expressed.

2.1

The Trabzon Sub-Region is studied in terms of urban and rural development since 1940. The region is one of the developing parts of the country, and the differences among urban areas are greater than rural areas, such as high density on the coastal part of the region and rapid population increase in urban areas against continious decline in rural population. While the number of urban centres is increasing (x), the number and the size of the rural centres are decreasing. Distribution of urban population by urban size is as follows :

% of tot.urban pop.	urban pop. size
7.5	less than 5000
26.3	5001-10000
28.1	10001-25000 (xx)
38.1	25001-over

---

x. The number of urban centers increased from 24 to 41 between 1940-1960

xx. Three major urban centers are : Trabzon : 97000, Giresun : 38000, Rize : 36000 pop.

By 1985, 47% of the region's population will live in urban centres as estimated by the state agencies.

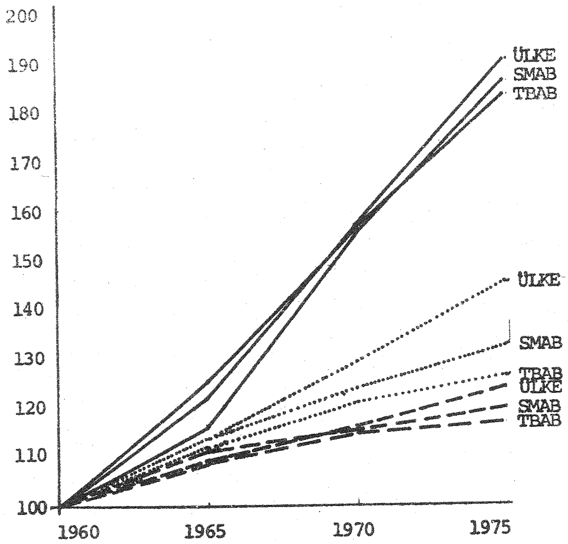
2.2
There are over 2000 villages (rural centres) in the region and the distribution of total rural population by rural centre size is given in the following table

% of tot. rural pop.	rural centre pop. size
2o.2o	less than 500
36.70	501-1000
20.89	1001-1500
22.22	1501-over

Increase in the number and the population size have doubled in the last group in the last ten years (see graph:1, maps:1, 2)

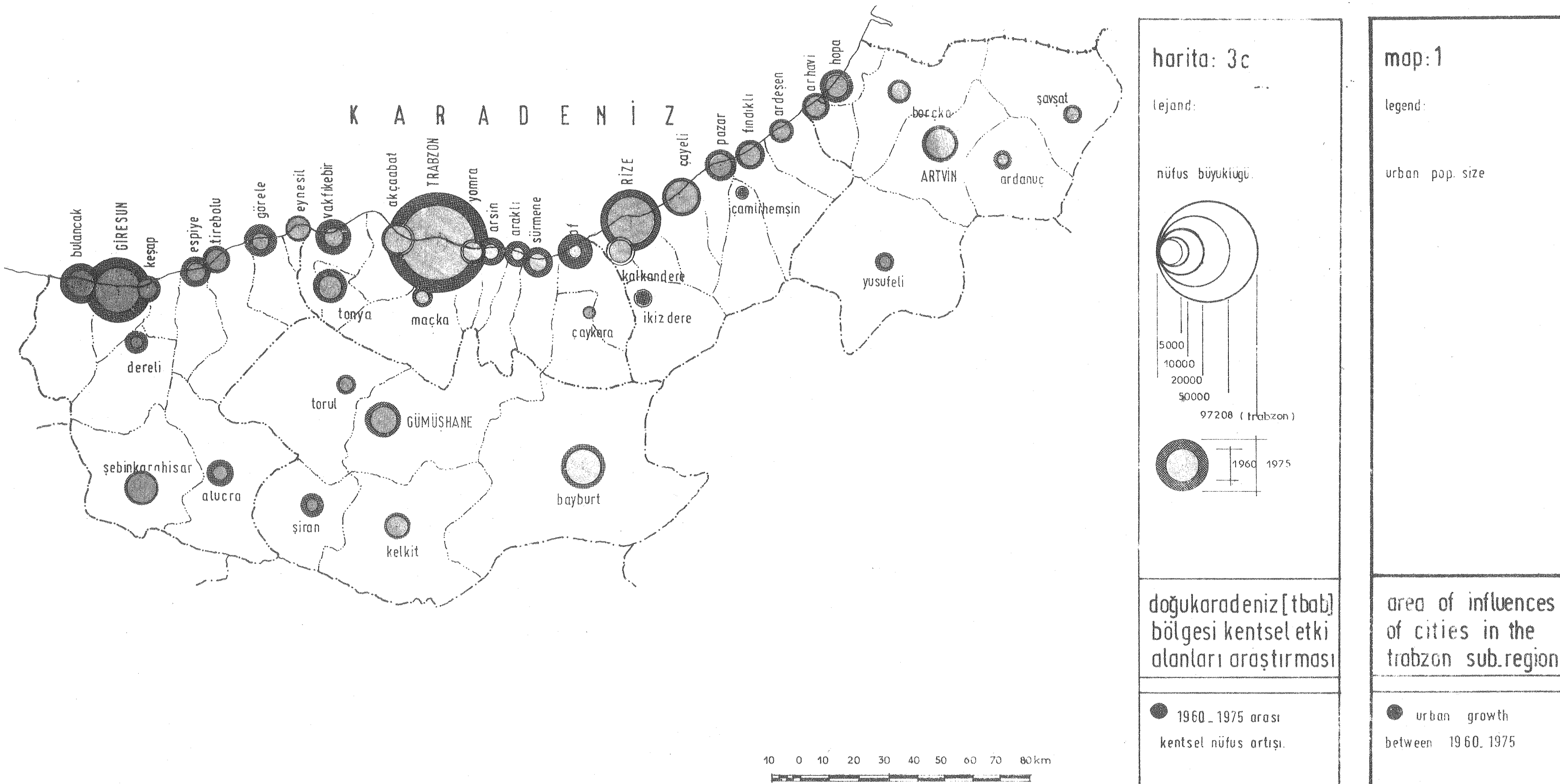
Graph : 1
The Trabzon Sub-Region (TBAB), The Samsun Sub-Region and National Population Growth :

Index: 1960=100

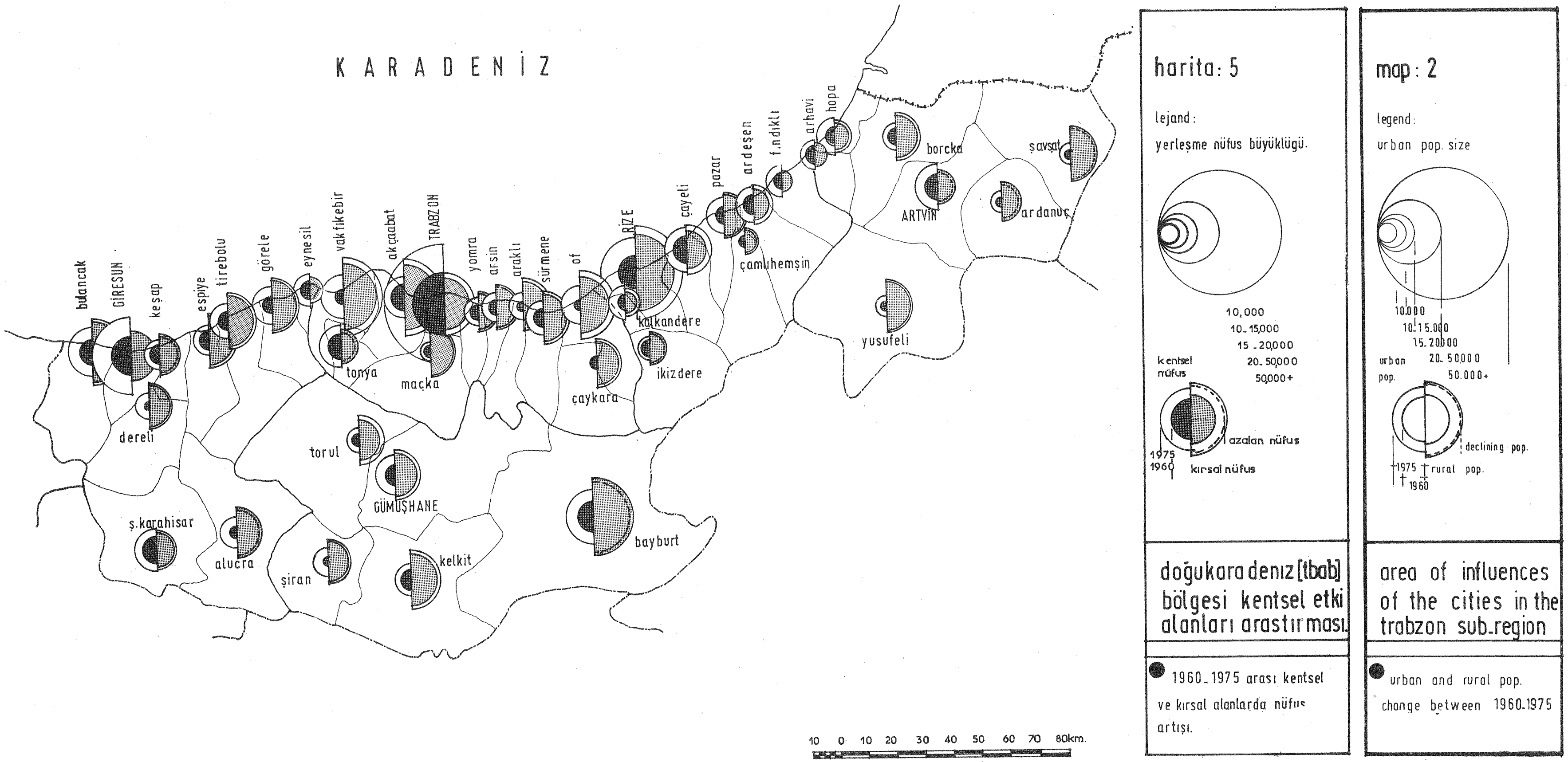


———— urban population
- - - - - - rural population
.... total population

ÜLKE: NATIONAL
TBAB: TRABZON SUB-REGION
SMAB: SAMSUN SUB-REGION



K A R A D E N İ Z
bulancak
GİRESUN
keşap
espiye
tirebolu
görele
eynesil
vakfıkebir
akçaabat
TRABZON
yomra
arsin
araklı
sürmene
of
RİZE
çayeli
pazar
fındıklı
ardeşen
arhavi
hopa
borçka
ARTVİN
ardanuç
şavşat
çamlıhemşin
kalkandere
ikiz dere
çaykara
yusufeli
tonya
maçka
dereli
torul
GÜMÜŞHANE
bayburt
şebinkarahisar
alucra
şiran
kelkit
10 0 10 20 30 40 50 60 70 80km
harita: 3c
lejand:
nüfus büyüklüğü
5000
10000
20000
50000
97208 (trabzon)
1960
1975
doğukaradeniz [tbab] bölgesi kentsel etki alanları araştırması
1960 _ 1975 arası kentsel nüfus artışı.
map: 1
legend:
urban pop. size
area of influences of cities in the trabzon sub.region
urban growth between 1960. 1975



KARADENİZ
bulancak
GİRESUN
keşap
espiye
tirebolu
görele
eynesil
vakfıkebir
akçaabat
TRABZON
yomra
arsin
araklı
sürmene
of
RİZE
kalkandere
çayeli
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f.ndıklı
arhavi
hopa
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ARTVİN
şavşat
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çamlıhemşin
ikizdere
çaykara
tonya
maçka
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GÜMÜŞHANE
ş.karahisar
alucra
şiran
kelkit
bayburt
10 0 10 20 30 40 50 60 70 80km.
harita: 5
lejand:
yerleşme nüfus büyüklüğü.
10,000
10-15,000
15-20,000
20-50,000
50,000+
kentsel nüfus
azalan nüfus
1975
1960
kırsal nüfus
doğukaradeniz [tbab] bölgesi kentsel etki alanları araştırması.
1960-1975 arası kentsel ve kırsal alanlarda nüfus artışı.
map: 2
legend:
urban pop. size
10.000
10-15.000
15-20.000
20-50.000
50.000+
urban pop.
declining pop.
1975
1960
rural pop.
area of influences of the cities in the trabzon sub-region
urban and rural pop. change between 1960-1975

Physical distribution of urban and rural centres also varies from the coastal part of the region to inland, 25 urban centres out of 41 are on the coast line. The average distance among urban centres on the coast is 14.9km.

2.3

Accessibility in the region has also been studied by producing a distance matrix among 41 urban centres. Then this matrix is converted into another matrix by weighting with road surface qualities and the speed made on them. By doing this a uniform distance matrix is produced. With this new matrix regional accessibility schemes are produced (see schemes : 1, 2). As a result of the accessibility analysis, it was not found a high correlation between urban size and accessibilty but there is a high correlation between the physical location of the urban centres and accessibility.

3.1

The centrality analysis has been done to show the urban hierarchy in terms of urban services and central functions in this developing region. To be able to show the regional urban hierarchy, a region-wide survey was carried out with the help of officials such as governors, mayors, education authorities, school headmasters, a group of students. During the survey two different types of data were collected related to urban central functions such as number of shops, education facilities, health services, administrative institutions, finance and insurance services, etc. The second type of data was related to the volume of interactions among all types of settlements-urban and rural - to provide those services mentioned above. People were asked where and how often they visit different level of centres to provide their needs.

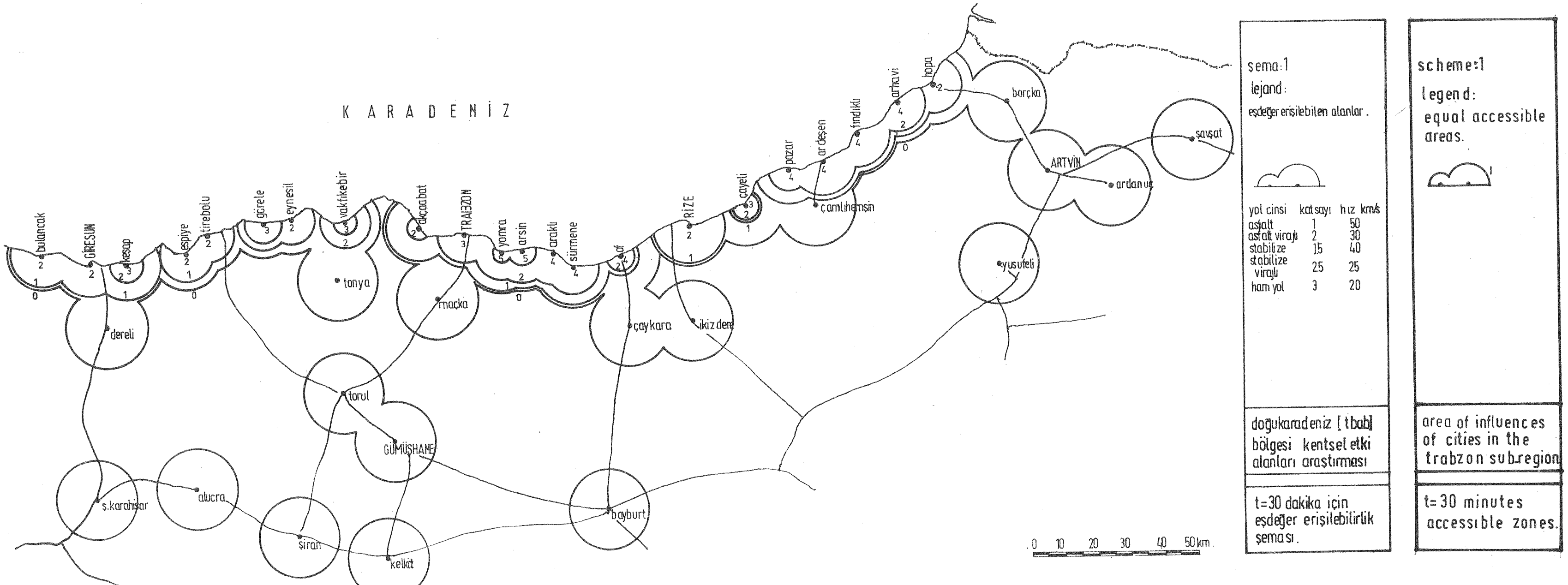
The centrality analysis was done by using Davies' centrality formula (x). Location coefficients of central functions and centrality indices were produced for each urban function and urban centres (xx).

(x) Davies' centrality index is : $C = t/T x 100$, see
Carter, H. The study of Urban Geography. Arnold, 1972, London.

(xx) Centrality analysis done for only urban centres.

3.2

As a result of the centality analysis five groups of central places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TRABZON
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of
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RİZE
ikizdere
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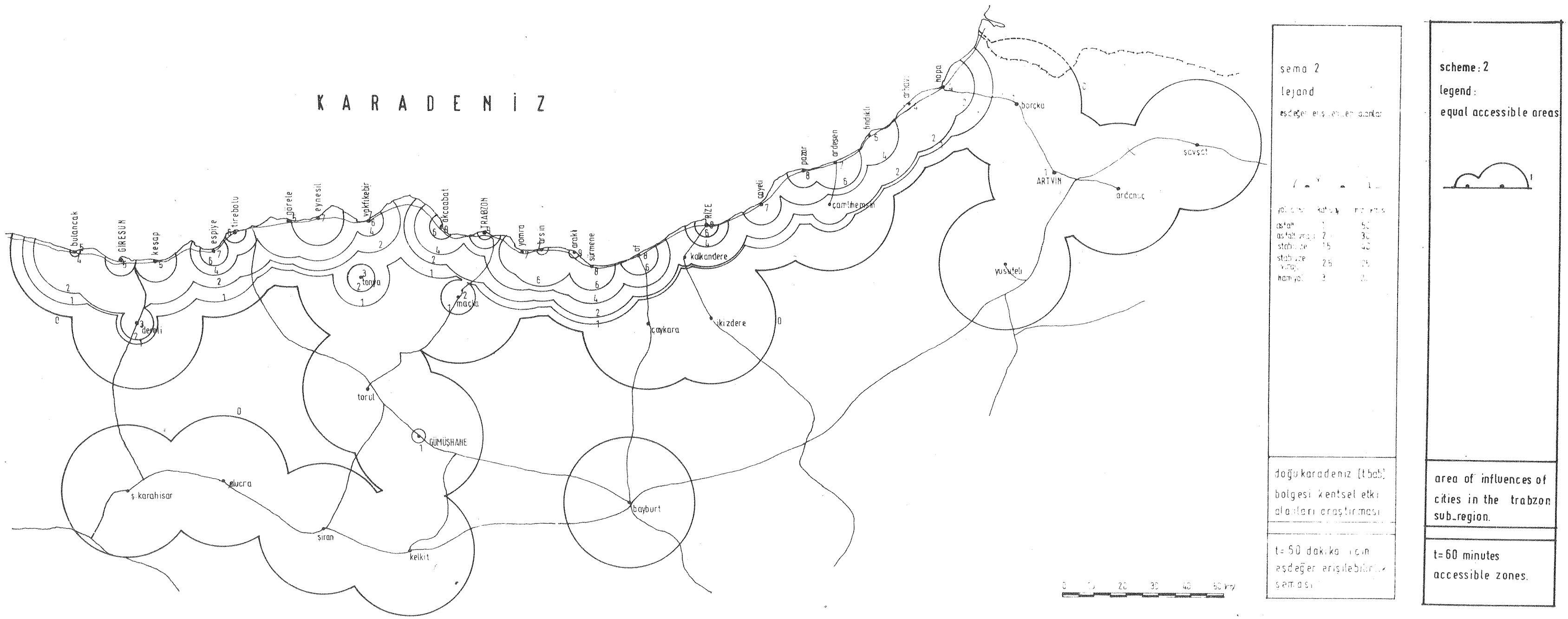
ardeşen
çamlıhemşin
fındıklı
arhavi
hopa
borçka
ARTVİN
ardanuç
şavşat
yusufeli
dereli
torul
GÜMÜŞHANE
ş.karahisar
alucra
şiran
kelkit
bayburt
0 10 20 30 40 50 km
şema:1
lejand:
eşdeğer erişilebilen alanlar.
yol cinsi katsayı hız km/s
asfalt 1 50
asfalt virajlı 2 30
stabilize 1,5 40
stabilize virajlı 2,5 25
ham yol 3 20
doğukaradeniz [tbab] bölgesi kentsel etki alanları araştırması
t=30 dakika için eşdeğer erişilebilirlik şeması.
scheme:1
legend:
equal accessible areas.
area of influences of cities in the trabzon subregion
t=30 minutes accessible zones.


KARADENİZ
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kesap
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tirebolu
görele
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vakfıkebir
akçaabat
TRABZON
yomra
arsin
araklı
sürmene
of
RİZE
kalkandere
çayeli
pazar
ardeşen
fındıklı
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hopa
borçka
ARTVİN
şavşat
ardanuç
yusufeli
dereli
tonya
maçka
çaykara
ikizdere
torul
GÜMÜŞHANE
bayburt
ş. karahisar
alucra
şiran
kelkit
0 10 20 30 40 50 km
şema 2
lejand
doğu karadeniz (tbab) bolgesi kentsel etki alanları araştırması
t=60 dakika için eşdeğer erişilebilirlik şeması
scheme: 2
legend:
equal accessible areas
area of influences of cities in the trabzon sub_region.
t=60 minutes accessible zones.

were identified.The hierarchy among urban centres is as follows :

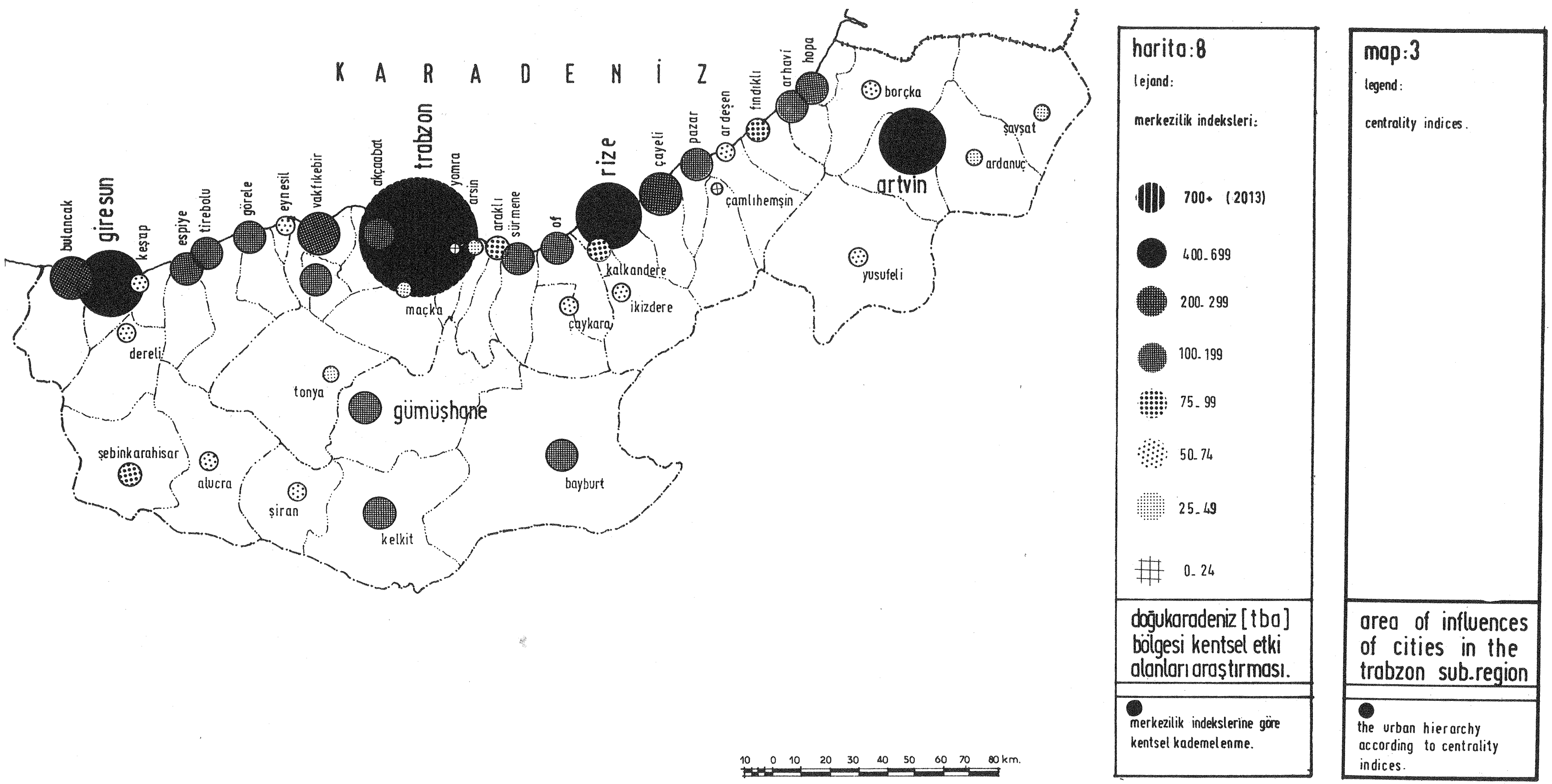
5. group centres : Trabzon
4. group centres : Rize, Giresun, Artvin
3. group centres : Vakfıkebir, Çayeli, Bulancak
2. group centres : Bayburt, Görele, Kelkit, Tirebolu, Akçaabat, Pazar, Arhavi, Tonya, Gümüşhane, Sürmene, Espiye.
1. group centres : Remaining 16 urban centres.

Grouping of urban centres by centrality was based on in-group and between group differences (see map : 3 table : 1) From this grouping the following correlations are found by regression analysis :

Urban centre size	/ no. of functional units.	r=0. 936
	/ no. of central functions.	r=0. 842
	/ centrality .	r=0. 967
Centrality	/ no. of functional units.	r=0. 957

Table : 1. Urban Hierarchy by centrality indices.
$C = t/T \times 100$

Trabzon	2013	Arhavi	140	Yusufeli	62
Rize	642	Tonya	130	Keşap	61
Giresun	545	Gümüşhane	123	Şiran	60
Artvin	479	Sürmene	123	Dereli	54
Vakfıkebir	278	Espiye	115	İkizdere	51
Çayeli	259	Of	114	Çaykara	51
Bulancak	221	Şebinkarahisar	97	Şavşat	49
Bayburt	167	Fındıklı	95	Maçka	48
Görele	164	Araklı	90	Arsin	42
Kelkit	160	Kalkandere	79	Torul	39
Tirebolu	151	Borçka	75	Ardanuç	39
Akçaabat	147	Alucra	73	Yomra	22
Pazar	146	Eynesil	67	Çamlıhemşin	20
Hopa	142	Ardeşen	67		


KARADENİZ
bulancak
giresun
keşap
espiye
tirebolu
görele
eynesil
vakfıkebir
akçaabat
trabzon
yomra
arsin
araklı
sürmene
of
rize
çayeli
pazar
ardeşen
fındıklı
arhavi
hopa
borçka
şavşat
ardanuç
artvin
çamlıhemşin
kalkandere
ikizdere
çaykara
maçka
yusufeli
dereli
tonya
gümüşhane
şebinkarahisar
alucra
şiran
kelkit
bayburt
10 0 10 20 30 40 50 60 70 80 km.
harita: 8
lejand:
merkezilik indeksleri:
700+ (2013)
400_699
200_299
100_199
75_99
50_74
25_49
0_24
doğukaradeniz [tba] bölgesi kentsel etki alanları araştırması.
merkezilik indekslerine göre kentsel kademelenme.
map: 3
legend:
centrality indices.
area of influences of cities in the trabzon sub.region
the urban hierarchy according to centrality indices.

Regional topography limits accessibility. For this reason accessibility does not play much role in the regional central place structure, except places like Trabzon, Rize, Giresun[x].

4.1

The area of influences are explained and a frequentation model is established. By using frequency of visits data which was obtained by questionnaires from over 2000 villages-rural centres-and 41 urban centres. Households were asked where and how often they visit those centres mentioned above to provide for their needs. Distribution of frequency of visits is analysed in the light of the following assumptions (see figure : 1)

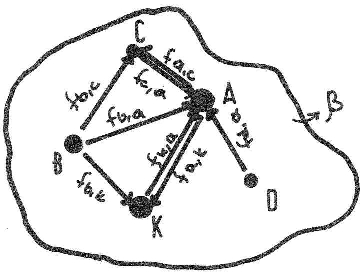


Figure : 1 A hypothetichal region ß and interaction between centres A, B, C, D, K

1. If there is one-way interaction from C to A, A has an influence on C.
2. If there is mutual interaction between A and C, $|f_{a,c} - f_{c,a}|$ showe the influencial centre and its force.
3. If $f_{c,a} > f_{a,c}$ C is under the influence of A in some degree or vice versa.
4. If $f_{c,a} = f_{a,c}$ C and A have equal influence (equal force).

Centre A may be in interaction with more than one centre like B, C, D, K. In this case total visits made to each centre (frequency of visits) can be found by the following equation :

F_A = total frequency of visits made to A

$F_{\bar{V}}$ = total frequency of visits made from A

(x) Correlation between no. of accessible places from each urban centre and centrality is : r 0.369

$$F'_{A} = f_{b,a} + f_{c,a} \cdots\cdots\cdots + f_{k,a} = \sum_{b}^{k} f = \sum_{1}^{n} f_{a}$$

$$F_{V} = f_{a,b} + f_{c,a} \cdots\cdots\cdots + f_{a,m} \sum_{b}^{m} f = \sum_{1}^{m} f_{v}$$

The centres in region $\mathcal{B}$ can be put in a hierarchy according to their field forces, and the area of influences can be presented by vectors connecting each centre (see figures : 2, 3).

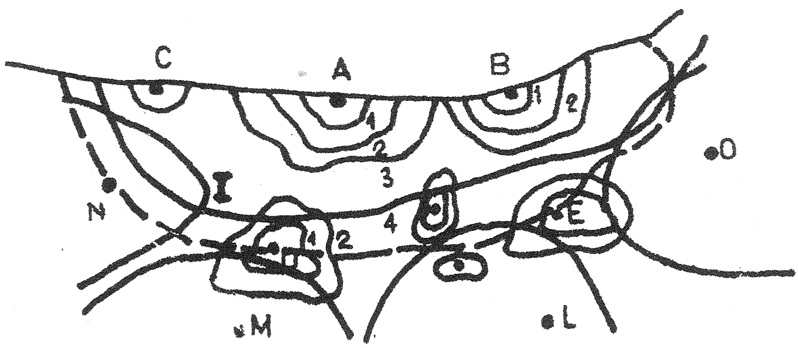


Figure : 2. Area of influences presented by vectors

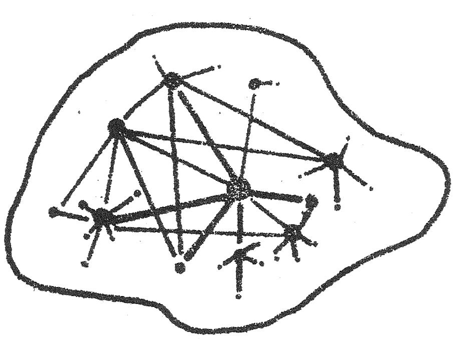


Figure : 3. Area of influences presented by vectors.

4.2
An origin-destination matrix based on the above assumptions is produced for computation of frequency of visits among centres. Each centres is identified by its census of population code number. This computation was done for all central functions to show functional specialization among them (see tables : 2, 3).

Table : 2 Origin -destination matrix

Central Functions	Origins of Visits	Destinations of Visits	Frequency of Visits (x)
f_{111}	0801.0.001	08	15
	0801.01.001	0805	18
	0801.01.001	61	10
	0801.01.001	0804.0.002	25
	....	......	..

It is possible to see from this matrix that a centre may be in interaction with several centres mutually or in one way. In this case total number of visits made from a centre is the total of visits made to those centres. The status of the centres depends on the difference of the frequency of visits made mutually. Ofcourse this definition is applicable only on provincial level. What happens if cross-boundary interactions exist ?. Here, for practical reasons, the computation procedure is somewhat different. The crossboundary interactions among centres in different provinces were calculated on the following two bases:

1. Interactions between centres in a province boundary are calculated in the matrix form as above, then presented on 1 : 100000 scale maps.
2. All cross-boundary interactions among the other centres are calculated additively either on the provincial centres, then directed to the final destination at the same level of provincial or sub-provincial centres, then presented on 1 : 500000 scale maps (see figure : 4).

4.3
The distribution of frequency of visits were examined seperately for each type of shopping and other services. The field force indices were produced to show the functional classification of urban centres. The hierarchy among the urban centres in terms of functional specialization were showed, then the catchment areas (range of goods and services) were found for major centres by regression analysis. Finally, additive field force indices were produced to show overall

(x): Visits made in the last two years.

$$F_{A} = f_{b,a} + f_{c,a} \ldots\ldots\ldots + f_{k,a} = \sum_{b}^{k} f = \sum_{1}^{n} f_{a}$$

$$F_{V} = f_{a,b} + f_{c,a} \ldots\ldots\ldots + f_{a,m} \sum_{b}^{m} f = \sum_{1}^{m} f_{v}$$

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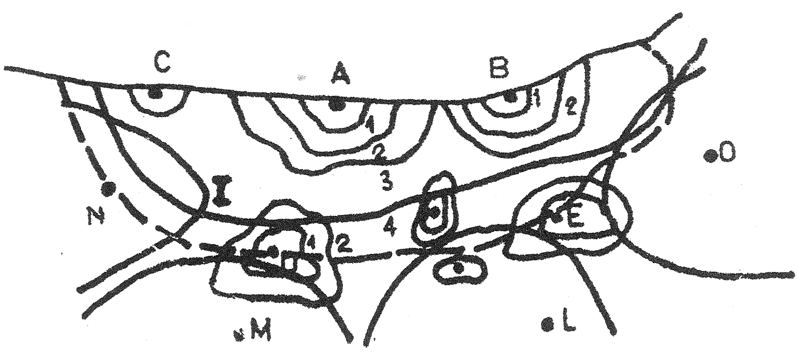
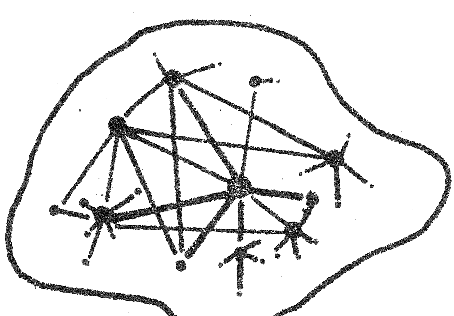


Figure : 2. Area of influences presented by vectors



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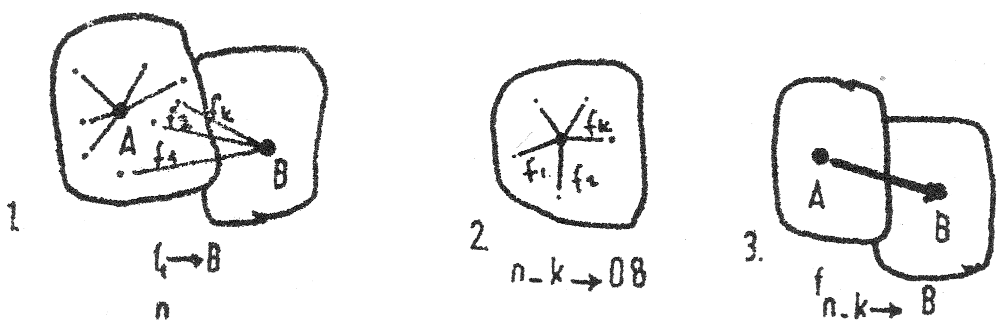
(x): Visits made in the last two years.

functional specialization and the area of influences for all type of goods and services (see tables : 3, 4, 5, maps : 4, 5).

Figure : 4 Calculation of cross-boundary interactions.

Origin of visits	Destination of visits	Total visits (frequency of visits)
Rural Centres	Previncial Centre	
(n-k)	08	$f_{(n-k)}$ $f_1 + f_2 + f_3 \ldots + f_k$

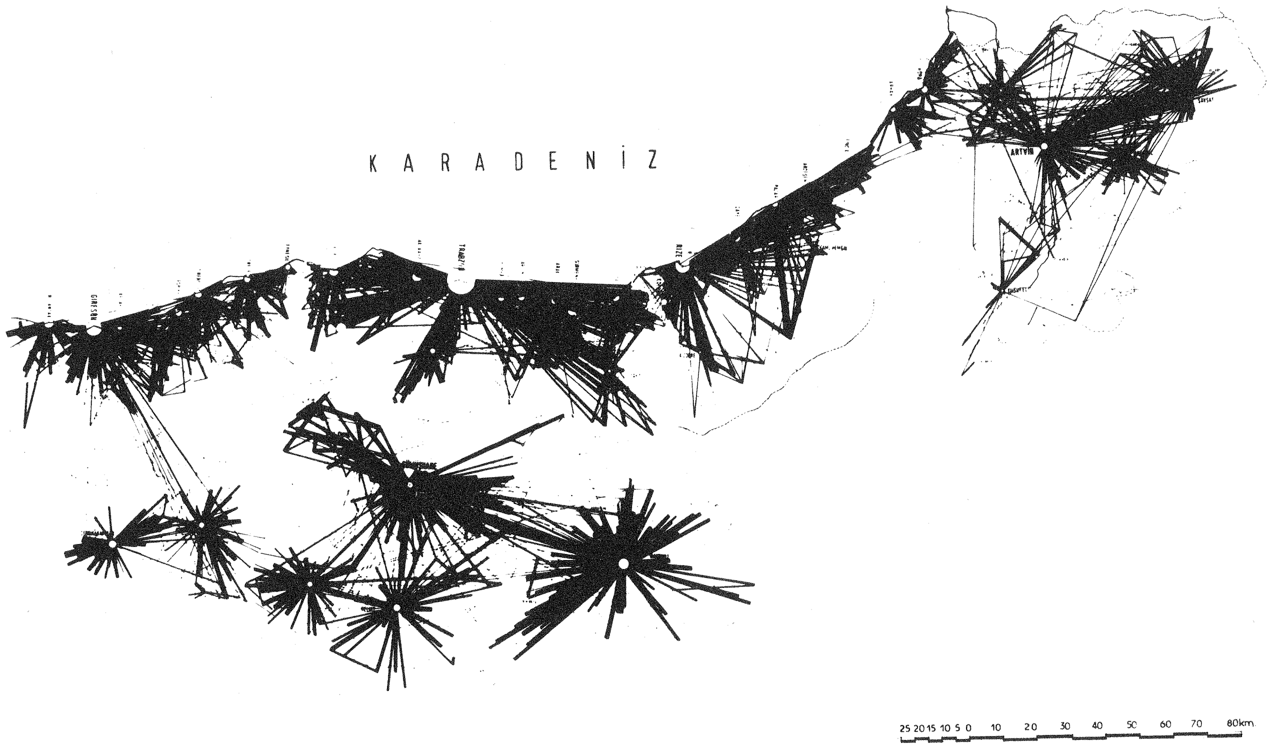


Interaction from rural centres to province or sub-provinve

Interaction from province to province

Table : 3. Area of influences in distance. (Range of goods)

Centres	Regression equation	r	km.
Trabzon	Y = 2999.93 - 13.46 X	- 0.614	216
Rize	Y = 2532.14 - 14.55 X	- 0.448	175
Gümüşhane	Y = 5779.36 - 49.77 X	- 0.623	116
Giresun	Y = 3698.70 - 38.55 X	- 0.514	96
Artvin	Y = 2131.23 - 26.98 X	- 0.865	78
Bayburt	Y = 12575.55-136.59 X	- 0.874	91
Kelkit	Y = 3024.38- 23.22 X	- 0.613	89
Pazar	Y = 1390.79- 17.07 X	- 0.305	80
Şavşat	Y = 3858.49- 57.15 X	- 0.864	66
Şiran	Y = 4854.65- 73.65 X	- 0.719	65
Of	Y = 4199.47- 47.72 X	- 0.517	52
Şebinkarahisar	Y = 11385.42-275.57 X	- 0.999	41
Vakfikebir	Y = 9239.58-233.53 X	- 0.703	40
Görele	Y = 6097.83-193.26 X	- 0.558	41



harita:20

lejand:

yerlesmeler arası toplam git_gel frekansı yoğunlugu: f/2 yıl.

200 100 50 10

devlet sınırı :
bölge sınırı :
il sınırı :

yerleşme büyüklügü:
50_100.000
20_50.000
15_20.000
10_15.000
0_10.000

f_{111_1121}

dogukaradeniz [tbab] bölgesi kentsel etki alanları araştırması.

haftalık, gereginde, olaganüstü ihtiyaclarla kişisel hizmetlerin karsılandıgı merkezler ve frekans yog genel durum (superpoze hali)

map: 4

legend:

density of the frequency of visits: f/2 years.

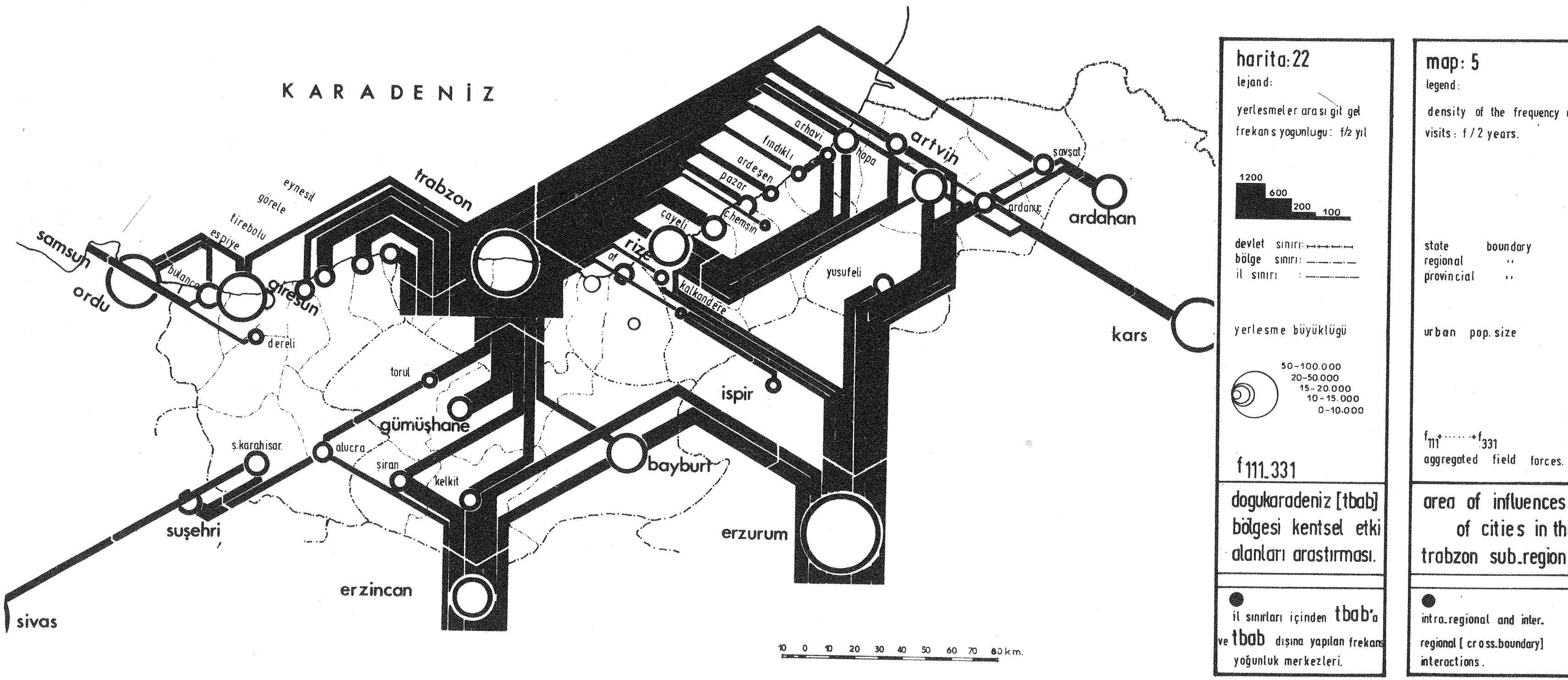
state boundary
regional "
provincial "

urban pop. size

$f_{111} + \cdots + f_{1121}$
aggregated field forces.

area of influences of cities in the trabzon sub.region

density of the frequency of visits at the centres for the provision of dayly, weekly, montly needs.

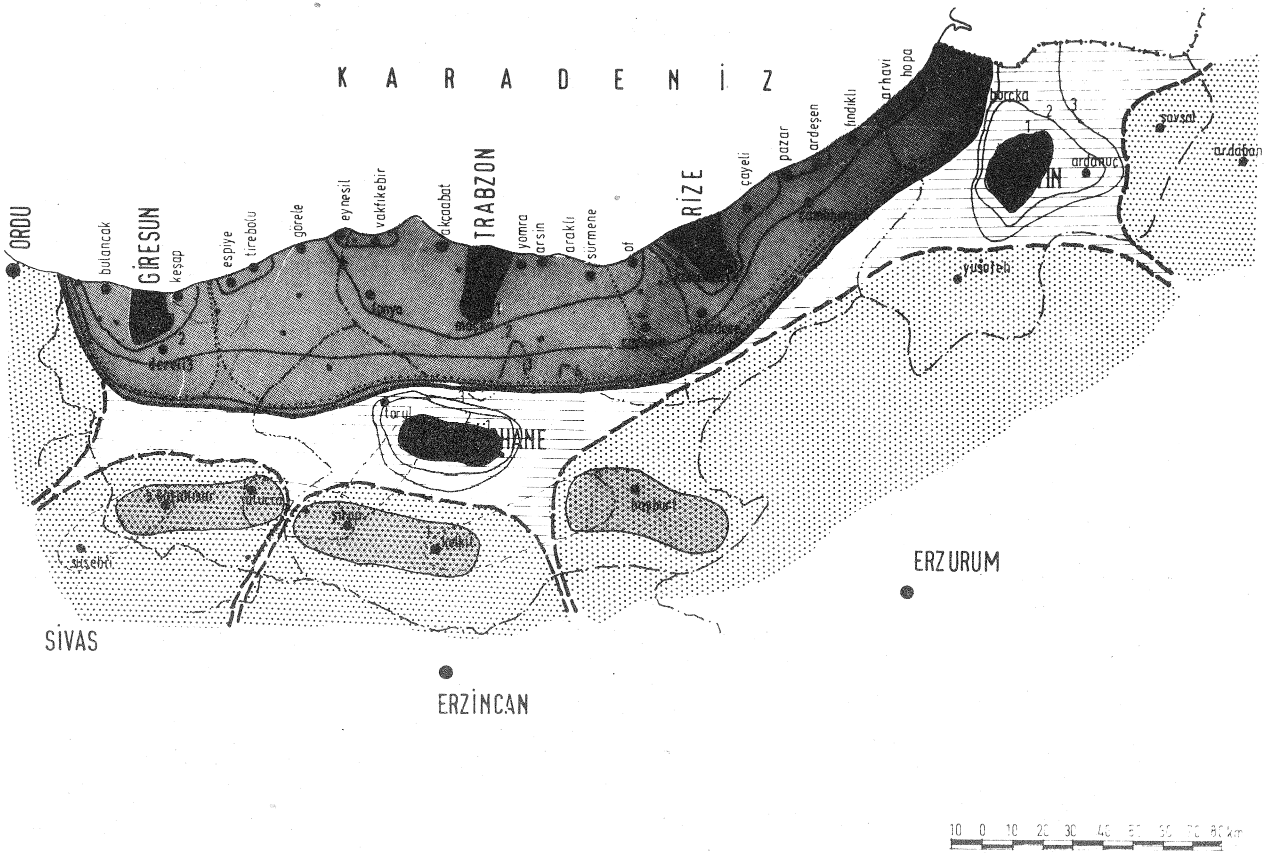

K A R A D E N İ Z
samsun
ordu
bulanca
espiye
tirebolu
görele
eynesil
giresun
dereli
trabzon
of
rize
çayeli
c.hemsin
pazar
ardeşen
fındıklı
arhavi
hopa
artvin
savşat
ardanuç
ardahan
kars
yusufeli
kalkandere
ispir
torul
gümüşhane
s.karahisar
alucra
şiran
kelkit
bayburt
erzurum
erzincan
suşehri
sivas
10 0 10 20 30 40 50 60 70 80 km.
harita: 22
lejand:
yerlesmeler arası git gel
frekans yogunlugu: f/2 yıl
1200
600
200
100
devlet sınırı:
bölge sınırı:
il sınırı :
yerlesme büyüklügü
50-100.000
20-50.000
15-20.000
10-15.000
0-10.000
f 111_331
dogukaradeniz [tbab]
bölgesi kentsel etki
alanları arastırması.
il sınırları içinden tbab'a
ve tbab dışına yapılan frekans
yoğunluk merkezleri.
map: 5
legend:
density of the frequency of
visits: f / 2 years.
state boundary
regional ,,
provincial ,,
urban pop. size
f111 ······ f331
aggregated field forces.
area of influences
of cities in the
trabzon sub.region
intra.regional and inter.
regional [cross.boundary]
interactions.

as Rize and Giresun.

- The regional functional specialization among the centres is seen in the provision of goods, building materials, personal services and health services.
- There are about 42 rural service centres, some of which act at the same level with some of the 2nd. and Ist. group centres in the regional urban hierarchy.

Finally, it is possible to put threshold limits for urban functions and services which are necessary for planning purposes. The functional specialization among the urban centres should accelerate as a regional policy. The Trabzon Sub-Region can be divided in two sub-regions, and the regional boundaries can be re-drawn as seen map 6.

This is a summary of :
Doğu Karadeniz Bölgesi Trabzon Alt Bölgesi (TBAB) Kentsel Etke Alanlarının Saptanması İçin Bir Yöntem: Etkileşim Esası. İTÜ. Mimarlık Fakültesi, Karadeniz Matbaacılık ve Gazetecilik A.Ş., Trabzon, 1978.



harita: 23

lejand

- - - - tbab'de oluşan yeni bir alt bölgenin gelişme yönü sınırları.
.... trabzon, rize, giresun etki alanı sınırı
— — — tbab dışı merkezlerin alanı sınırları.
——— tbab'nin bölgesel etki alanı sınırı
-·-·- ülke sınırı
—·—·— tbab yasal sınırı
— — — il sınırı
• kırsal hizmet merkez (köy kent)
● ilçe merkezi
● il merkezi
1 birinci derece etki alanı

dogu karadeniz [tbab] bölgesi kentsel etki alanları araştırması.

● tbab ve bölge dışı kentlerin etki alanı sınırları

map: 6

legend:

- - - - sub-sub regional boundary
.... area of influences of trabzon, rize, giresun
— — — area of influences of neighbouring regions.
——— area of influene of trabzon sub-region [proposed boundary]
-·-·- national boundary
—·—·— regional boundary
— — — provincial boundaries.
• rural service centre
● urban centre [county]
● urban centre [town]
1st. level area of influence
2nd. " "

area of influences of cities in the trabzon sub-region

● area of influences of the trabzon sub-region and the neighbouring regions.

A PROPOSAL METHOD FOR OBJECTIVE MEASUREMENT OF BUILDING FACADES IN ENVIRONMENT OR THEIR TWO DIMENSIONAL MODELS-drawings- IN ARCHITECTURAL DESIGN FROM THE AESTHETIC VIEW.

Dr. KUTSAL ÖZTÜRK

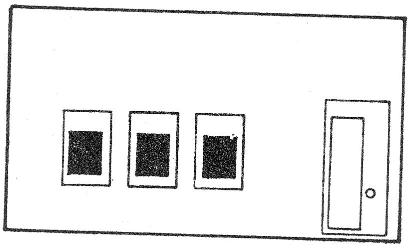
This thesis presents a method for objective measurement of building façades or their two dimensional models-drawings in architectural design from the Aesthetic view.

In chapter 1, the problem is introduced and the aim of study is defined. Some visuel examples are given in the history of Architecture related with the study.

In chapter 2, the existing methods for subjective and objective measurement of façades, are discussed and given some examples.

The Semantic Differential (SD) of Osgood et al. has proven to be a reliable, valid and practical instrument the subjective measurement and also Semantic Rating Scale (SRS) of Sanoff et al. But the subjective impressions of people have to be related to "objective" properties of the façades in order to accound for the subjective differences.

For objective measurement of façades three methods have been proposed so far in the literature. Firstly ratings and estimates of the frequencies of occurence of certain features (e. g. number of storeys, of flats, of balconies, of windows, of window forms, of roof surfaces, estimated age of the building etc.) (1973), cf. Wright (1973) and Krampen (1974, 1978). Secondly, the Type-Token-Ratio (TTR) was introduced by Krampen in Architecture (1974). The TTR originally used in linguistics to estimate the "flexibility" of speech production by dividing the number of <u>types</u> of words used (e. g. noun, verb, adjective, etc.) by the number of <u>tokens</u>, i. e. by the frequencies of occurence of these word types within a given sample of speech (cf. Osgood, 1958) This procedure has been shown to apply easily also to facades, by dividing the number of different types of façades parts (e. g. different types of windows. of balconies, of doors, etc.) by the number of realizations in these type classes in a given sample of facades. This is a simple example for showing the measurement of TTR:



Façade :

1	wall
1	door
3	windows

Type (T)		Token (T)	Ratio (R)	
window	: 1	3	1/3	: 0.33
wall	: 1	1	1/1	: 1.00
door	: 1	1	1/1	: 1.00
			TTR	: 2.33

The third method information measurement can be applied in two ways. Either an inventory of all façade parts in a sample is taken as the repertory and the information measure is calculated on the basis relative frequencies (- probability occurence) of the façade parts, or the surface of a façade is subdivided in to grid units which are labelled according to their content (e. g. roof surface, wall surface, window surface, etc.) These measurement based on the Information Theory. According to the Theory, The probability that any one group of signs will register on the mind of a beholder at any given level relates to the frequency with which the sign is repeted. Thus the content of a scene is represented mathematically as follows.

$$I = \sum_{i=1}^{i=n} N_1 \log_2 \, 1/P_{(i)}$$

where :

I Total information content in bits

n Total number of different types of element

i any integer from 1 to n

P(i) The probability of an element type (i) being noticed

N_i total number of elements of type (i).

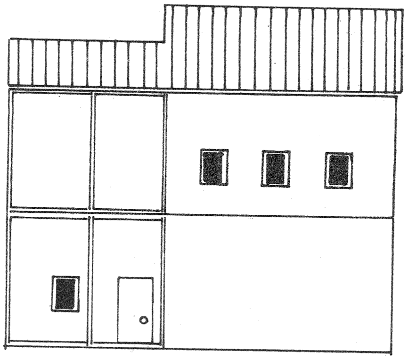
The procedure is first to list all the different elements the architectural scene contains and to record after each the number of times this element recurs. Adding together of all results gives the number of bits the building rates.

It is possible to use some tables about ($\log_2 n$) and ($n \log_2 n$) for the calculation, but in this thesis the computer programme which is shown below, was used.

```
10  DISP " A = "  ;
20  INPUT  A
30  DISP " X = "  ;
40  INPUT  X
50  Z = A * (LGT(X/A)) / LGT(2)
60  PRINT A,X,Z
70  GO TO 10
```

These are the examples :

FAÇADE :



elements of the façade	total numbers
window :	4
door :	1
wall :	6
roof :	1
	total :12

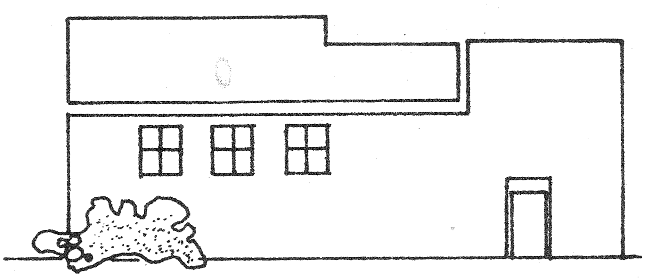
4 : different elements

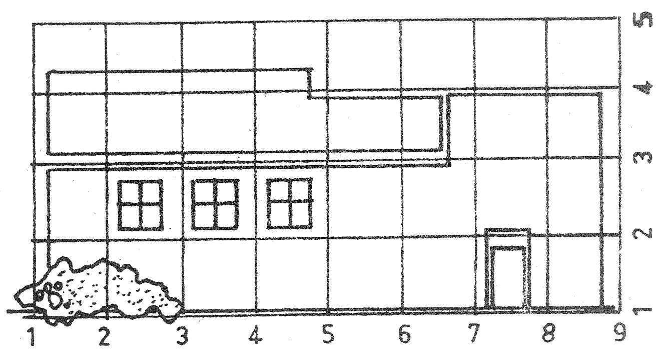
12: total

$$I = 4.\log(12/4) + 1.\log(12/1) + 6.\log(12/6) + 1.\log(12/1)$$

$$I = 4.\log 3 + \log 12 + 6.\log 2 + \log 12$$

The surface of a façade is subdivided in to grid units which are labelled according to their content.





roof : (?)
door : (%)
air : (×)
window : (+)
Wall : (/)
green : (=)

X	X	X	X	X	X	X	X
?	?	?	?	?	?	/	/
/	+	+	+	/	/	/	/
=	=	/	/	/	/	%	/

To open up the problems and the advantages of the informational approach to measurement in this field we may return to theories of formal aesthetic and in particular to the theory advanced by G. D. Birkhoff.

Depends onBirhoff : 'The typical aesthetic experience may be regarded as compounded of three successive phases :

1. a preliminary effort of attention, which is necassery for the act of perception, and which increases in proportion to what we shall call the complexity (C) of the object,

2. the feeling of value or aesthetic measure (M) Which rewards this efford, and finally,

3. a realization that object is characterized by a certain harmony, symmetry, or order (O), more or less concealed, which seems necessary to the aesthetic effect.

This analysis of the aesthetic experience suggests that the aesthetic arise primarily because of an unusual degree of harmonious interrelation within the object.

More definitely, if we regard M, O and C as measurable variables, we are led to write :

$$M = O/C$$

and thus to embody in a basic formula the conjecture that the aesthetic measure is determined by the density of order relations in the aesthetic object. "

In chapter 3, the proposal method is explained. The method has three steps :

I : Abstraction
II : Determining, relationship between forms of façade to each other and whole of façade, and relation with environment as silluette.
III : Digitizing and calculation.

Two dimensional model of façade -e. g. drawing- is syntacticly abstracted. Determining visual forces of structural skeleton of abstracted model of façade for micro -aestetics of façade and silluette for macro- aesthetic of façade. And then values of micro

6

and macro aesthetics of façade is calculated with DAÇ (table of evaluation) aided. There are 3 experimental studies related with the steps of method. (appendix I, the experiment 1, 2, 3) The proposal method can be formulated like this :

$$C_e = \frac{(\sum B_e / \sum n) + S}{2}$$

X

C_e Numerical aesthetic merit of façade

$\sum$ Sigma

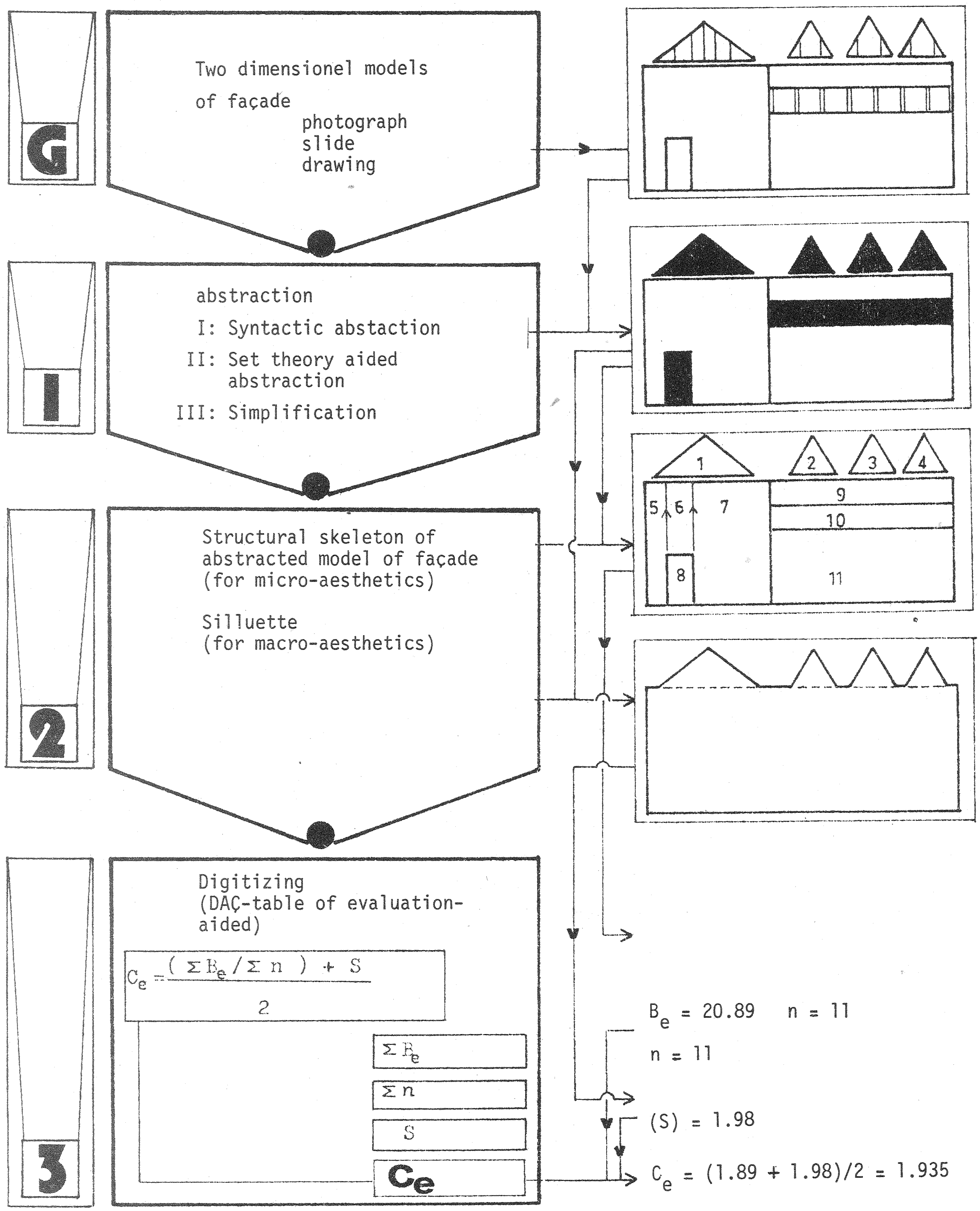
B_e Numerical aesthetic merit of forms ofvisual forces of structural skeleton of abstracted model of façade

n Number of forms

S Numerical aesthetic merit of silluette

In Chapter 4, some examples demostrating the application of the proposed method. And also measurements of the proposed method are compared with other subjective and objective measurements which are applicated on the same examples.
The results can be summarized as follows :
There is a high significant correlation between the measurements of the proposal method and the subjective measurement, which gives too high correlation coefficient.
(r = 0.96 , 0.893 , 0.01)
There is a correlation between measurements of the method and (TTR) measurements
(r = 0.84, 0.714, 0.05)
There is also a correlation between the measurements of the method and (I) information measurement..
(r = 0.76, 0.714, 0.05)
In these study, The data is treated by "X (chi-square)" significance test for each paired comparison.
And Spearman's rank-order correlation is used.
All the 'experiments 'and their results are in apendix I,
'Set Theory 'and 'Information Theory 'are summerized in other appendixes.

FLOW CHART FOR THE PROPOSAL METHOD



DAÇ

TABLE OF EVALUATION
DEĞERLENDİRME ARACI ÇİZELGESİ

GEOMETRICAL FORMS Biçimler		G.D.Birkhoff's Aesthetic Merits M = O/C	+ 1 aided value	relativities		New Aesthetic values for the operation (Dr.K.ÖZTÜRK)
SQUARE		1.50	2.50			2.50
RECTANGLE		1.25	2.25	ratio of sides 0.50-0.70	+ 1	2.25
				0.40-0.50 0.70-0.80	+1/2	1.75
				0.40< and 0.80>	∓0	1.25
TRIANGLE		1.16	2.16	equilateral triangle	+ 1	2.16
				isosceles triangle	+1/2	1.66
				triangle	∓ 0	1.16
HEXAGON		0.83	1.83			1.83
PENTAGON		0.90	1.90			1.90
PARALELLOGRAM		0.75	1.75			1.75
RHOMB		0.75	1.75			1.75
HEPTAGON		0.71	1.71			1.71
OCTAGON		0.62	1.62			1.62
NONAGON		0.55	1.55			1.55
ISOSCELES TRAPEZOID		0.50	1.50			1.50
DECAGON		0.50	1.50			1.50
TRAPEZOID		0.25	1.25			1.25
POLYGON		5/n	1-5/n			1-5/n
DISORDERED TETRAGON		-0.25	0.75			0.75

THE SOCIAL SCIENCES IN ARCHITECTURAL EDUCATION: A PROPOSED APPROACH

Dr. ŞENGÜL ÖYMEN GÜR

When the future role of the architect requires a social knowledge and sensitivity, it becomes important to incorporate social scientific knowledge into architectural education.
Although the idea of rationalizing the design process had in its core the desire for basing design on its social and economic context, social scientific knowledge is still misinterpreted and underestimated in architectural education today. Social sciences do not merely provide facts to be fed into the design process, nor do they only provide methods by which architecture can be analyzed. They actually consist in an important body of knowledge which can aid designers to reject, alter or accept a plan, a project or a strategy.

For a healthy collaboration between social scientists and architects, the social sciences have to be transmitted to architectural students as a unified body of knowledge, as a going concern in a disciplined mode of argument in the field of architecture. This will clarify the way social scientists conceive of problems, tackle them and select appropriate methods and techniques for research. An integrated theory of architecture is also necessary for this collaboration. An integrated theory (a theory which accounts for both the internal and the external - i. e. task-environment of architecture) can be achieved only through appropriate premises and principles of logic, critical methodology and proper logistic explanations which derive from valid answers to questions like 'what, for whom, where, when and why'.

Architecture can neither be conceived nor taught separately from the social system out of which it evolves. Architectural philosophies adopted by the schools of architecture, however, disregard logistic inquiries and merely focus on the personal scale of architecture (internal environment).
Schools, in general, are meant to socialize the philosophy of the existing systems everywhere, therefore even the professional schools such as the schools of architecture avoid questioning the system 's value. They prefer to focus on the question of ' how ' rather than ' what, for whom and why '.

Professional education is a complex process which must be viewed as an intersection of social demands and professional methods and skills. Thus the primary task of any architectural school is to accept, develop and transmit a generative adaptable, reality-based, practice-oriented philosophy of the profession; to organize curricula and the research areas in the light of this understanding; and to assist in the inclusion of this task-environment oriented philosophy into the intellectual units of education, first of all.

One basic strategy to counteract the unintegrated and reduced philosophies of architecture, biased design principles, abstract methodologies, idle creativity etc. in architectural design educations is to establish a basic, comprehensive theory course, upon which possible curricular innovations and research areas could be coherently planned.

A basic theory course is that which transmits an integrated theory of architecture by duly emphasizing the man-society-architecture relationship as well as those of design elements, properties and criteria with regards the user.

It should consist of three levels: a) the universal-phenomenal, b) the local-concrete, and c) on specific cases.

The goal of the first level is to transmit a conceptual model of architecture as the intersection of living, non-living systems, social systems, individual systems, and other man-made systems such as arts, technology, planning, law and history, etc. The second level should aim at transmitting the local parameters of the task environment in which the prospective architect is most likely to perform. The last level should take a critical approach to architectural design process and methodologies; and specifically should aim at bringing to the fore the ethical issues involved in programming (in terms of methods, strategy, need-meaning-value dialectics of the user). Thus theory course should render an efficient framework for logistical analyses prior to design work-shops where the design phase of the overall making process in architecture can be emphasized.

Although the knowledge of the type of commissions architects get today indicate that the architect is very often held responsible of the life of total communities, application proves that architect-society dichotomy is as strong as it was a century ago: the architect is divorced from his public; society is alienated from the architect; professional prestige is lost; and many architectural problems of social origin continue.

This situation requires that the architect should be educated in fully conceiving and participating in the solution of those socio-architectural problems that demand action. Social knowledge and sensitivity should be acquired first. Only then can action follow.

Despite the fact that today's architect is expected to appreciate the socio-econo-political implications of architectural decisions, as well as the environmental, technological, cultural and psychological ones, the vital interconnection between architecture and society ; between social scientists and architects is underestimated in the curriculum at most architectural schools today.

In order to fill this important gap in the curriculum this study analyzes society-architecture interactions through two major concept couples such as society-social change and architecture - society exchange ; produces the principles of incorporating social sciences into architectural education ; and proposes a core theory course in the architectural curriculum comprehending the aforementioned concepts for the purpose of aiding the young architect in grasping intellectually the two interacting phenomena, the two interacting disciplines and the two interacting tasks.

The architest's failure to react to problems such as excessive use of metarial resources in society (land, building technology and materials, funds) ;[1] unrestricted land speculation,[2] unquestioned environmental protection regulations,[3] arbitrary design canons in architecture, urban design and planning,[4] and dysfunctional architecture[5] which results in psychological strain, etc.[6] has led some to doubt

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R. Starr, Housing and the Money Market, Basic Books Press, New York, 1975.

J. Jacobs, The Economy of Cities. Random House Publishers, New York, 1969.

B. Brolin, The Failure of Modern Architecture, Van Nostrand Reinhold Publishing Co., New York, 1976.

M. Pawley, Architecture versus Housing. Praeger Publishers, New York-Washington, 1971.

2

M. MacEwen, Grisis in Architecture. RIBA Publications Ltd., London, 1974.

3

M.E. Brooks, Housing. Eouity and Environmental Protection; The Needless Conflict. AIP Publications, Washington, 1976.

A. Fein, Frederick Law Olmsted and the American Environmental Tradition. Braziller, Planning and Cities Series, 1972.

R. Burchell and D. Listokin, The Environmental Impact Handbook, Transaction Books, 1975.

Creating the Human Environment. AIA Report, by G. McCue, W. Ewald, Jr. and Midwest Research Institute, University of Illinois Press, Urbana-Chicago-London, 1971.

4

G. Broadbent, Design in Architecture, John Wiley and Sone, London-New York -Sydney-Toronto, 1973.

whether there should be any planning or design school. (1) Rejecting any form of planning and design stems from socio-political nihilism or cultural nihilism. Socio-political nihilists are those who are either radicals of conservation or radicals of change. The former support the present order and, therefore, they attempt to obstruct any plan which seeks to introduce new social responsibilities. The latter, on the other hand, prefer toleration of the existing chaotic order, convinced that it will eventually destroy itself. Therefore,the two extremes agree on the futility of planning and design --and, hence, on the futility of schools of design.

Cultural nihilists are those who argue the immunity of cultural values versus compulsory planning values; and prefer to let things evolve in time, for insincere reasons very often. Thereby they also allude to the futility of schools of design.

Nevertheless, since the schools are powerful socializing institutions of society, and are responsible for fostering planning and design principles which are said to be unjust, discriminatory and irresponsible, then a strong reverse attitude towards planning and design can only be professed and spread by socializing institutions as strong as schools.

Schools are indispensable for counter-social-izing tasks. Thus they should remain to carry out the goal of fostering social thought and innovations in planning and design.

It is the tasks of architectural educstors:

1. to understand and accept the validity of interconnections between society and architecture, between social scientists and architects:
2. to re-organize the curriculum upon this understanding of

C. Alexander, "A City is not a Tree", Architectural Forum. April (pt. 1) and May (pt. 2), 1965.

5

M. Mead, World Enough: Rethinking the Future. Little Brown and Co., New York, 1976.

(footnote 5 cont'd)

J. Jacobs, The Life and Death of Great American Cities, Random House Publishers, New York, 1959, alludes to psychological strain without fully defining it.

6

M. H. Turan, Environmental Stress: An Ecological Approach with Special Reference to Housing, Ph. D. dissertation, Columbia University, 1974, attemps to define "strain".

1

T. Maldonado, Design Nature and Revalution, transl. by M. Domandi, Harper and Row Publishers, New York, 1967, pp. 8-11.

architecture, and to establish proper courses relative to the definition of the subject-matter;

3. to employ a school policy to interact with life environment for the purpose of retaining student-society of, thus, altogether undertaking a socio-physical responsibility to the immediate environment.

The links between the social and the physical environment are understood by educators to some extent. Even some non-professionals are cognizant of the same intricate relationship between building and structure of social system. But, a society orientation in architectural education has only been stated in the form of global goals-and in goals alone. For example, the outcome of a widely distributed questionnaire lists the following goals:

" a) A student (or graduate) should be able to work effectively within the real world constraints of present day practice...

b) A student (or graduate) should be able to comprehend the continuing changes in the social, economic, scientific and technological setting of our society. He should be able to constantly renew and adapt his abilities in response to these changes...

c) A student (or graduate) should be able to formulate a concept of better environment beyond present day constraints to give direction to his adaptability...[1]

These goal statements indicate recognition of the concerns signified above. But as far as the studies of architectural curricula are concerned, some do not go beyond statistical research,[2] some are procedural[3] (answering the question of how rather than why and what) and many of them are piecemeal.[4]

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1 R. L. Geddes and Bernard P. Spring, A Study of Education for Environmental Design; AIA Sponsored Report, Princeton University Press, Princeton, New Jersey, 1967.

2 i. e. S. Y. Hassid, Architectural Education in the U.S.A. :Our Changing Environment. Ph. D. dissertation, Berkeley, California, 1967.

3 i. e. Geddes, Loc. cit.

4 Hassid, Loc. cit. outline of articles on architectural education.

5 C. Norberg-Schulz, Intentions in Architecture. The MIT Press, Cambridge, Mass., 1965.

The above goals of education and with them the allured role of the architect in society require that he should be introduced to the social sciences in such a way that he can collaborate effectively with social scientists, especially at a senior stage in his career when he has a greater measure of design initiative, when collaboration among professionals becomes more imperative, and when he is likely to have a better opportunity of influencing that collaboration.

But the few curricular amendments, such as courses on sociology, economy and psychology etc. are taught in splendid isolation 5 at most architectural schools today with the few exceptions where an attempt is made to unite psychological themes and architectural themes under proper titles ; and to tie the theoretical fundamentals to design practices. However, the second attitude is neither dominant nor sufficient and the entire effort needs reworking.

Prevalent applications of an isolated nature evolve from faulty approaches of architects and architect-philosophers to the social sciences. Concern with social sciences in the sphere of architecture, actually, emerged by and through architect researchers who attempted to improve the design approach in an effort to counteract the Bauhaus emphasis on creativity and self expression.

Their goal was to base design on its social, economic and psychological context. They developed methods to analyze design problems and to synthesize solutions in order to avoid an irrational variety of solutions and risk in design.[1]

Many abstract models of design process and a couple of models of the design phase have accumulated since the inception of the rationalizing idea[2]; all have their pros and cons. However, as educational innovation they did not prove successful for various reasons :

1. Instead of being built into studio efforts, they were added to the architectural curriculum as a further responsibility, at most schools.
2. Or as in the case of same schools when methods were applied in the studios, they even became ends in themselves rather than means. Emphasis laid on the testing of various methods and techniques led to the study of the ' means ' as problems

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1 D. P. Crant, <u>Systematic Methods in Environmental Design : An Introductory Bibliography.</u> Council of Planning Librarians, Exchange Bibliography No. 302, August, 1972.

2 <u>Emerging Methods in Environmental Design and Planning.</u> G. T. Moore, ed., The MIT Press, Cambridge, Mass., 1970.

rather than the original architectural problems themselves.

3. Also, the automation techniques employed by the architectural methodologists and the studio participants led to over abstraction of the community and to pragmatic architectural decisions. People became numbers.[2]

In other words, architect-educators of rationalist persuasion looked to the social sciences for their potential contribution, in one of two ways : One way has been to regard the social sciences as merely providing simple facts which can be fed into the design process. Here social science is regarded as a tool of design. The other way has been to regard the social sciences as the paradigm of architecture ; that architecture could be a science with firm roots in psychology ; that the methods and tecniques of social sciences could be easily applied to architecture to provide statistich. Both the empricists and positivists are wrong. Facts of the empricists are not universal truths first of all. Secondly, methods of the positivits are to be used better by a professional social scientisi than by an architect, Thirdly, both the empricists and to positivists overlook the intuitive element in design.[3]

Whereas it is much important for the young architect to learn how the social scientist thinks about a new problem, what governs his decisions about how to tackle it, and two exactly his findings get incorporated into policy decisions about a plan or building rather than social scientist 's detailed methods of inquiry.[4]

> " The educational objective therefore must be to put the young architect in a position intellectually - and if possible in practice, to graps the principles of a relevant social science sufficiently well to make collaboration possible and effective. "[5]

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1 N. Negroponte, The Architecture Machine. The MIT Press, Cambridge, Mass., 1970.

2 Statements on methodologies are to be expanded in Chapter II of this study and statements on the application of them are to be expanded in Chapter III. of this study.

3 M. Broady, Social Theory in Architectural Design, ARENA, January, 1966, pp. 149-154 points to the misconceptions

4 M. Broady, " Sociology in the Education of Architects ", Architectural Quarteriy, April 1969, pp, 49-52.

5 Ibid., p. 49.

Thus a social science course in architectural education should be established in an effort to familiarize the young architect with the interactions between social systems and architecture (as one of subsystem of social system), in other words, with the exchange processes. The relationary domain between the two professions should thus be crystallized; the total social-physical tasks of future architects should be clarified ; hence a set of socio-architectural questions should be identified prior to design.

Today other than the formal and descriptive history courses, the procedural methods and methodology courses, the elementary sociology and economy courses, there is no one course in architectural curriculum which comes close to meeting the aforementioned objectives, and yields a comprehensive basic knowledge conducive to social consciousness and sensitivity.

It is time now to support the procedural and deseriptive theories of architecture by an explanatory course which carries out various goals of architectural education at the same time.
Besides, a central course as proposed here is coherent with the views of those researchers who seek in the psychology of learning an objective basis of contradictory approaches to architectural education : the concensus among these researchers is that the elementarist (structuralist) approach, which prefers to teach the elements of design with emphasis on the links between the elements and the whole, plus a conceptual model of the whole is a ' better ' approach to education than the case-study approach, the one which prefers to teach various concepts and elements of design as they relate to the specific case problem studied in the studio.

The view is based on experiments which confirm that concepts learned as free moving elements combined with previousiy learnad concepts to form new and unexpected combinations not experienced before. The deduction is that through such learning the knowledge recipient, can be better prepared for potential innovations.[1]

Therefore to put it briefly again, this study attempts to point out what properties are ignored in conceiving and teaching architecture thus far ; how they are ignored ; why they are ignored.

Thus, it formulates the institutional tasks of the schools of architecture and proposes an educational strategy to assist in the inclusion of long-neglected properties of architecture into education.

1

H.H. Williamson, " Psychological Basis of Architectural Education ", Progressive Architecture, March 1969, pp. 72-80.

In the first chapter, this study demonstrates architecture-"task-environment" interconnections and the nature of decisions which concern architecture. It identifies sociological questions an architect should learn to ask-and, if possible answer; and defines the architect's task with respect to society through a conceptual model of architecture.

In the second chapter the study tests the validity and sufficiency of the existing theories of architecture in terms of logic, methods and logistics with the conceptual model developed in the first chapter, for the purpose of demonstrating the insufficiency of architecture's long-standing philosophical concerns from Vitruvius onwards.

The third chapter examines the underlying reasons as to why internal environmental theories of architecture pervade schools of architecture. It points to the system-determining and socializing aspects of the schools of architecture as one example of social institutions. This chapter then proposes that, for the purpose of realization of publicly determined goals of education, the system-determining and socializing powers of the educational institution be used for counter-socialization; that is, for leading both students and practicing architects to a progressive conception of architecture. To do this, the study proposes a core course in the curriculum, based on the notions of social change and architecture-society exchange; and produces principles of a society-oriented school policy.

PROBLEMS OF WIND DRIVEN RAIN AND A METHOD TO PREDICT ITS INTENSITY ON BUILDINGS

Dr. MESUT ÖZDENİZ

Problems associated with the penetration of rain water has been increased in Turkey and throughout the world, with the introduction of new building techniques and materials into the building industry.

The aim of this study is to analyze and solve the problems associated with wind driven rain penetration.

In the first chapter, building defects were classified and discussed according to the origin of and to the results of failures. Building defects associated with driving rain has been shown to constitute a high percentage among other types. The reasons for this can be summarized as :

- Importation of building forms and systems without making the necessary adjustments to the local climate.
- Cracks on the building shell that occur due to the faulty design.
- Inadequate specification of design.
- Designing without considering the quality of available workmanship.
- Inadequate research on rain penetration.
- Inadequate testing methods for rain penetration.
- Uncertainty. of the climatic stresses on components that has to be weathertight.
- Early weathering of the joint sealing materials.
- The tendency for building with less materials which is possible by the introduction of new building materials and systems. However, the performance of these materials and systems under climatic stresses are not known, and the principles to achieve weathertightness with them are not established yet.

It was concluded that to solve the problem, architects or designers should be provided with information on physical phenomena related with rain penetration. Thus; all the physical phenomena, involved in the motion of the rain water in the atmosphere and on the building shell, were reviewed in chapters 2 and 3.
The promlems of wind driven rain penetration appear very frequently in the exterior joints. The solution of this complex problem is

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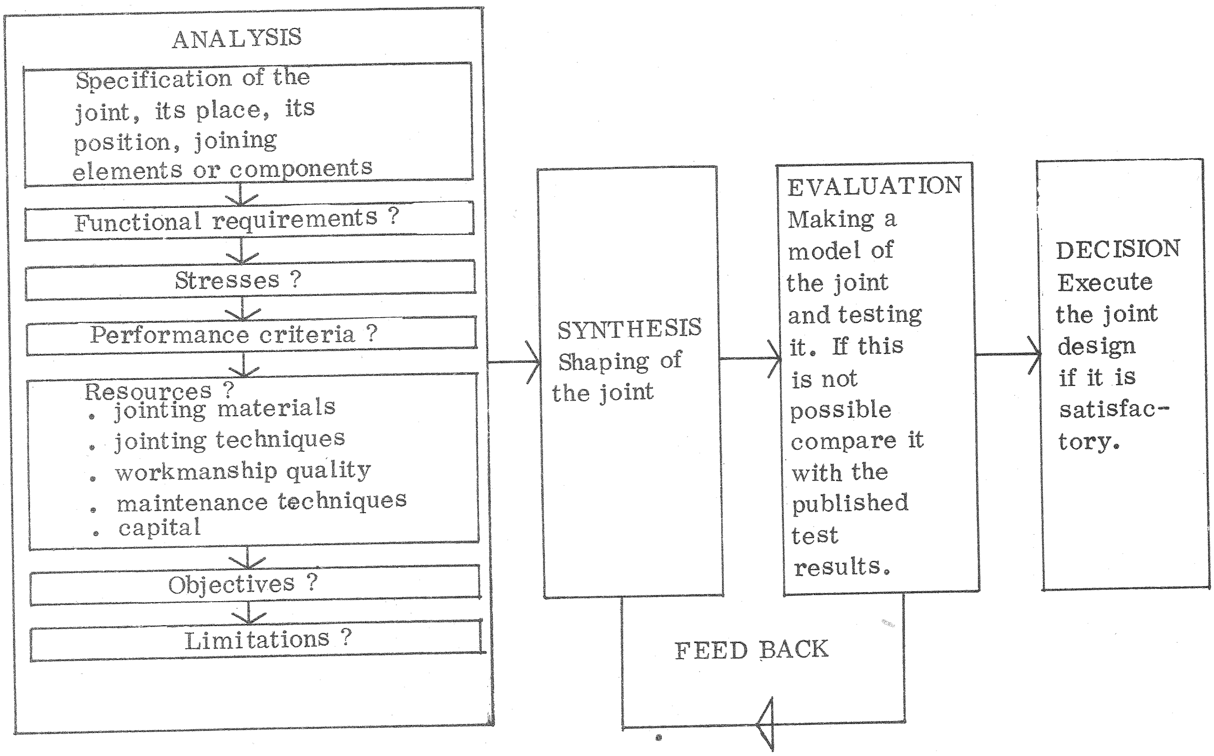
possible if the design of weathertight joints is not thought separately from the entire building design. So, the principles of weathertightness employed in traditional and present day buildings were studied to see if these principles can be applied with the new building techniques and materials. It was shown in chapter 4 that many of these principles can be applied and be effective in reducing the risk of rain penetration.

The design of exterior joints is a tecnical problem of building design and the systematic ways of joint design should be adopted. Architects cannot solve the problem of joint design like an industrial designer does. Because he has to make buildings with longer service life, with less materials and be economical. In chapter 5, the flow diagram of the weathertight joint design based on the performance approach and the general design process were given. (FIG. I)

FIGURE I. Flow diagram for the joint design.



For this purpose, the architects should be provided with information on the effectiveness of the weather protective features on building exterior shell, under various driving rain stresses. In chapter 6, available test results on this subject were discussed. It was concluded that these tests should be renewed for a set of stresses by the correct simulation of driving rain.

The second information needed for the design of weathertight joints is the prediction of driving rain stress on building. When this is provided; the joints will be designed for the correct exposure, designed joints will be tested under the correct stresses, acceptable joint testing methods will be developed, and the ready made components like windows whose performance are known will be selected more economically.

In chapter 7, the existing methods employed for this purpose were discussed. Of these methods ;

- The direct measurements of wind driven rain on buildings are costly. They give information only for the type of building on which the measurements are made. (1)
- British Driving Rain Indexes are of approximate basis. They do not give information on the instantenous rates of driving rain. They can be used to indicate the most exposed direction at a place like Britain in which wet winds could come from any direction. However, in a continental climate all the winds do not bring rain. (2)
- U. S. S. R. Tiblis Zone Research and Design Institute Method uses the below equation, as in the British Driving Rain Index Method, to compute the driving rain intensity for each storm. (3)

$$\frac{Ş_{düş}}{Ş} \quad \frac{u}{V_t}$$

Where $Ş_{düş}$ is the driving rain intensity on a vertical surface,
$Ş$ is the horizontal rain intensity (as measured by meteorological offices)
u is the wind velocity ,
V_t is the terminal velocity of the mean size raindrops for the given horizontal rain intensity.

This equation is written on the assumption that raindrops move in the horizontal direction at a speed equal to the speed of the wind and in the vertical direction at their terminal velocity. This equation is correct above the gradient height. In the boundary layer, however, wind velocity decreases with the decreasing height. A mean size raindrop cannot adjust its horizontal velocity component to the decreasing wind velocity. It cannot also adjust its velocity to the sudden changes in wind velocity. Thus, the horizontal component of the raindrop velocity is faster than the mean wind velocity.

It is the progress of the method to use the reoccurance period of the driving rain computed. However, the use of the method is possible by obtaining special data from the meteorological stations.

- Two similar methods were proposed in 1974 Rotterdam CIB/ RILEM symposium on " Moisture in buildings " by Sandberg and Rodgers et al. Both methods use the forces that act on the raindrops to compute the driving rain on the center line of a high, long building facade at a flat land. The use of these methods are not practical. They necessitate quantitative information on airflow around the buildings which is difficult to obtain, and they give driving rain intensity for the less exposed position of the building. Furthermore, these methods can be used only for the buildings on a flat land. (4, 5)

It was concluded that a new method is necessary with the following provisions :

- It should give more precise results than the existing methods,
- It should be possible to be used in every kind of topography,
- It should be practical,
- It should use data published normally by meteorological offices,
- It should give information not only for vertical surfaces but also for inclined surfaces,
- It should consider the meteorological data with their reoccurance period,
- It should take into consideration ground roughness, building height, wind velocity, rain intensity, temperature etc.

This is only possible by taking into account all the forces that act on raindrops and then by solving the equations of raindrop motion. This approach was also adopted by SANBERG (1974) and RODGERS et al. (1974). However they used two dimensional equations to compute the driving rain impact on the center line of a building facade standing on a relatively flat land.

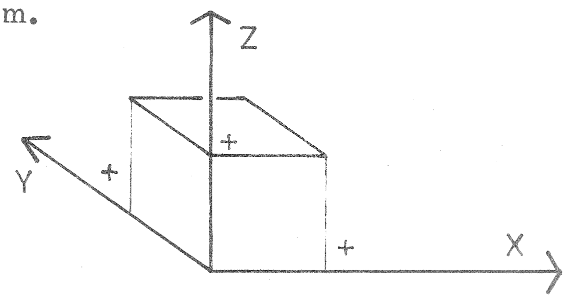
In chapter 8, three dimensional equations with the improved assumptions were given to compute driving rain impact on any parf of a building standing on any kind of land.

The total force acting on a raindrop can ba written as ;

$$\sum F = m\,a$$

Where, $\sum F$ is the total force
m is the mass of the raindrop
a is the acceleration of the raindrop.

FIGURE 2. Positive directions along the x, y, z axes of the Cartesian coordinate system.



The components of the total force acting on the raindrop along the x, y, z axes of the Cartesian coordinate system (FIG 2.) can be written as;

$$F_x = m\, a_x = -F_{Dx}$$

$$F_y = m\, a_y = -F_{Dy}$$

$$F_z = m\, a_z = -F_{Dz} - F_w$$

Where a_x, a_y, a_z are the components of acceleration along the x, y, z axes

F_{Dx}, F_{Dy}, F_{Dz} are the components of the drag force along x, y, z axes

F_W is the weight of the raindrop.

The drag force F_D acting on a raindrop can be written as;

$$F_D = -\frac{1}{8}\pi\, d_d^2\, \rho_h\, (v - u)\, |v - u|\, C$$

Where d_d is the diameter of the raindrop
ρ_h is the density of the air
v is the velocity of the raindrop
u is the velocity of the wind
C is the coefficient of drag.

The weight of the raindrop can be written as;

$$F_W = m \cdot g \left(1 - \frac{\rho_h}{\rho_d}\right)$$

Where g is the acceleration due to gravity
d is the density of the drop.

If these last two equations are substituted, acceleration of the raindrop along the x, y, z axes can be written as ;

$$a_x = - \frac{0.75 \quad \rho_h \, C_x \, (v_x - u_x) \quad |v_x - u_x|}{d_d \quad \rho_d}$$

$$a_y = - \frac{0.75 \quad \rho_h \, C_y \, (v_y - u_y) \quad |v_y - u_y|}{d_d \quad \rho_d}$$

$$a_z = - \frac{0.75 \quad \rho_h \, C_z \, (v_z - u_z) \quad |v_z - u_z|}{d_d \quad \rho_d} - g \left(1 - \frac{\rho_h}{\rho_d}\right)$$

In these equations acceleration is a function of the wind velocity which changes with height and around the building. So the equtions can be solved by numerical integration. After a short time increment (dt), the new velocities and the new positions of the raindrops along the x, y, z axes are given by the following equations ;

$$v_x = - \frac{0.75 \quad \rho_h \, C_x \, (v_x - u_x) \quad |v_x - u_x|}{d_d \quad \rho_d} \, dt + v_{xi}$$

$$v_y = - \frac{0.75 \, \rho_h \, C_y \, (v_y - u_y) \quad |v_y - u_y|}{d_d \quad \rho_d} \, dt + v_{yi}$$

$$v_z = \left[- \frac{0.75 \quad \rho_h \, C_z \, (v_z - u_z) \quad |v_z - u_z|}{d_d \quad \rho_d} - g \right] dt + v_{zi}$$

$$X = - \frac{3}{8} \, \frac{\rho_h \, C_x \, (v_x - u_x) \quad |v_x - u_x|}{d_d \quad \rho_d} \, (dt)^2 + v_{xi} \, dt + X_i$$

$$Y = - \frac{3}{8} \, \frac{\rho_h \, C_y \, (v_y - u_y) \quad |v_y - u_y|}{d_d \quad \rho_d} \, (dt)^2 + v_{yi} \, dt + Y_i$$

$$Z = \frac{1}{2}\left[\frac{-\frac{3}{4}\ \rho_h\ C_z\ (v_z-u_z)\ |v_z-u_z|}{d_d\ \rho_d} - g\right](dt)^2 + v_{zi}\ dt + Z_i$$

Where v_{xi}, v_{yi}, v_{zi} are the initial velocities of the raindrop along the x, y, z axes

X_i, Y_i, Z_i are the initial positions of the raindrop along the x, y, z axes.

The coefficient of drag used in the above equations depends on the size and shape of the raindrop, and on the velocity of the raindrop relative to the air. So, there is a relation between the coefficient of drag and the Reynolds number. The Reynolds number is the ratio of the inertial forces to the viscosity and given by the equation

$$Re = \frac{d_d \cdot \rho_h\ |v - u|}{\eta h}$$

where ηh is the viscosity of the air.

It is not possible to fit the relation between the Reynolds number and the coefficient of drag into a single equation within the limits of reasonable error. Instead, the Reynolds numbers scale were divided into smaller ranges and for each range different emprical equations were proposed. They were based on data provided by GUNN and KINZER (6) By this procedure the average error involved in the calculation of drag coefficient is less than 1 %. (TABLE 1)

The predominant raindrop size was defined by BEST as the raindrop size which constitutes the highest percentage of water in one cubic meter of air. Its relation with the rain intensity is given by the following equation ;

$$d_e = 0.001\ Ş^{0.232}$$

Where d_e is the predominant drop size, m.

Ş is the rain intensity on a horizontal surface, mm/m^{2}h.

The amount of water present in the air for any horizontal rain intensity can also be calculated by the use of the equation proposed by BEST. (7)

$$S_M = 67\ Ş^{0.846}$$

where S_M is the amount of water per unit volume of air, mm^3/m^3

Variation of wind speed with height depends on the surface qualities of the ground and formulated by DAVENPORT as ; (8)

$$(u_H / u_G) = (H / H_G)^s$$

where u_H is the wind velocity H meters above the ground, m/s

u_G is the gradient wind velocity, m/s

H_G is the gradient height, m

s is the power law exponent which depends on the roughness of the ground. (TABLE 2.)

Quantitative information on wind velocity variation around the buildings are limited to a few building types. It is necessary to obtain this data by wind tunnel studies.

By taking a predominant size raindrop at grandient height and tracing its motion till it hits the building, it is possible to find the velocity and the angle with which it will hit the building. Then, multiplication of the velocity component of the raindrop perpendicular to the surface, by the amount of rain water present in the air will give the driving rain intensity on the surface. The flowchart to compute the raindrop impact velocity and the angle was given in FIGURE 3.

The use of this method is still very complex and far from the level of architectural use. It was thought that there would be some correlation between the free driving rain computed by raindrop tracing method and the hardest driving rain impact on buildings which is observed at the top corners of the buildings. By the term " free driving rain " it was meant driving rain in the absence of buildings. So, only the x, z axes were used. The experiments designed for this purpose were evaluated together with the measurements of other research workers. Findings indicate a high correlation between the measured and computed driving rain.

A number of graphs, based on data obtained by this simplified method, were produced to save the architects from using a computer. The computer program in Fortran IV to compute the raindrop impact velocity was also given for those interested with more accurate results. (FIGURE 4)

TABLE 1: Emprical Relations Between Re and C.

RE RANGE	EQUATION FOR THIS RANGE
$0 < R_e \leq 1.0$	$C = 24 / R_e$
$1.0 < R_e \leq 2.4$	$C = \frac{24}{R_e} + \frac{6}{1+\sqrt{R_e}} - \frac{6}{e^{R_e}}$
$2.4 < R_e \leq 100$	$C = \frac{24}{R_e} + \frac{6}{1+\sqrt{R_e}} + 0.29$
$100 < R_e \leq 800$	$C = \frac{24}{R_e} + \frac{6}{1+\sqrt{R_e}} + 0.26$
$800 < R_e \leq 1400$	$C = \frac{24}{R_e} + \frac{6}{1+\sqrt{R_e}} + 0.30$
$1400 < R_e \leq 1800$	$C = \frac{24}{R_e} + \frac{6}{1+\sqrt{R_e}} + 0.35$
$1800 < R_e \leq 2100$	$C = \frac{24}{R_e} + \frac{6}{1+\sqrt{R_e}} + 0.40$
$2100 < R_e \leq 2700$	$C = \frac{24}{R_e} + \frac{6}{1+\sqrt{R_e}} + 0.45$
$2700 < R_e \leq 3000$	$C = \frac{24}{R_e} + \frac{6}{1+\sqrt{R_e}} + 0.50$
$3000 < R_e \leq 3200$	$C = \frac{24}{R_e} + \frac{6}{1+\sqrt{R_e}} + 0.55$
$3200 < R_e \leq 3500$	$C = \frac{24}{R_e} + \frac{6}{1+\sqrt{R_e}} + 0.60$
$3500 < R_e \leq 3600$	$C = \frac{24}{R_e} + \frac{6}{1+\sqrt{R_e}} + 0.65$

FIGURE 3 : Flow chart to compute the raindrop impact velocity and the angle.

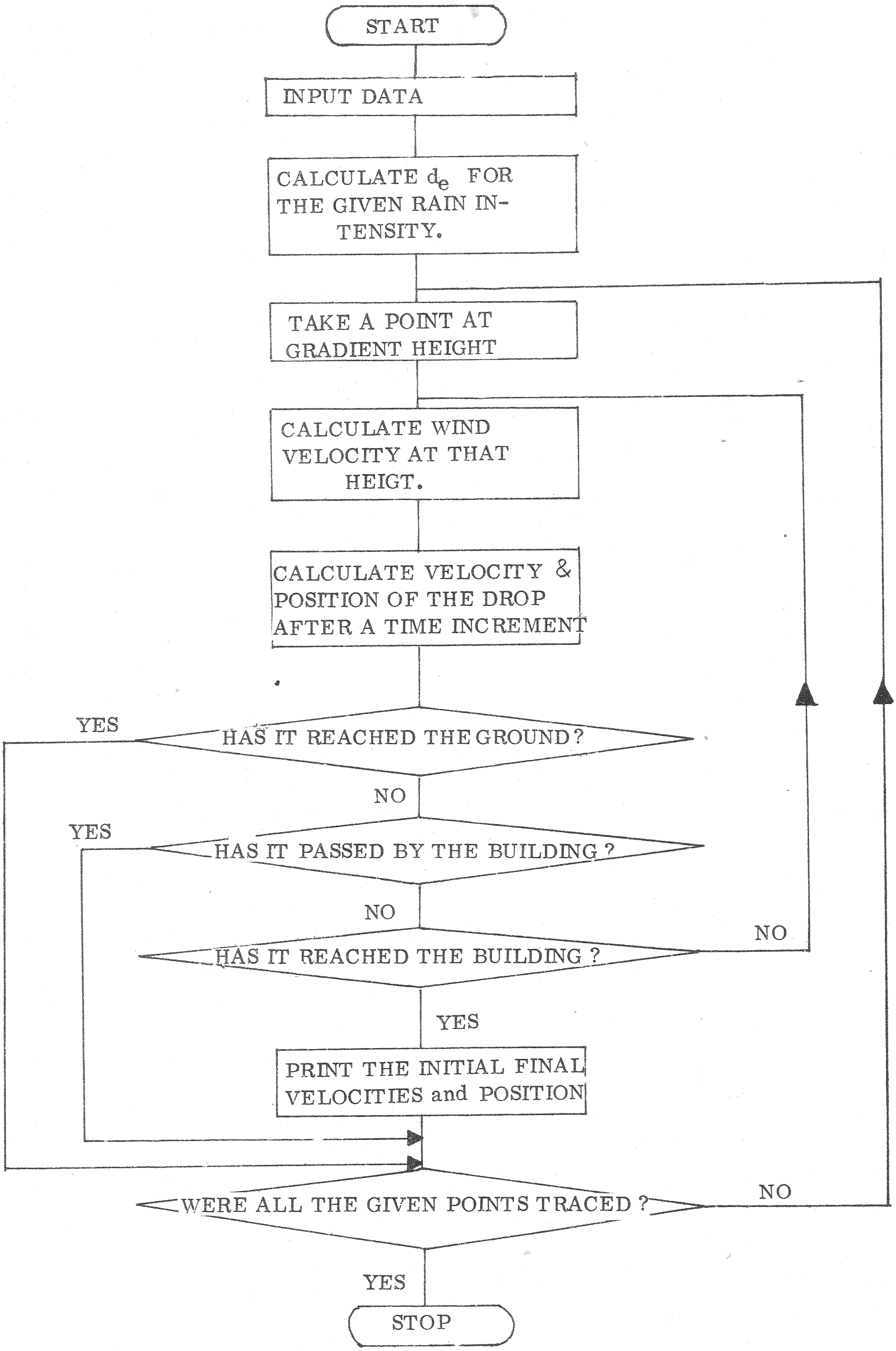


TABLE 2 : Power law exponents (s) for the ground roughness catagories and the gradient heights (H_G).

Terrain	s	H_G (meter)
Flat open country	0.16	274
Rough wooded country, city suburbs	0.28	396
Heavily built up urban centers, hilly areas,	0.40	427

The correct graph will be found by selecting the nearest higher values which are given at the right top corner of each graph. The heavy curve on the graph gives the trajectory of the predominant size raindrops. The dotted curve gives the horizontal velocity component of the raindrops. The vertical component which is the terminal velocity was also given on the right upper side of each graph. For the vertical surfaces ; the cosine of the angle between the trajectory and the surface normal should be multiplied by the resultant velocity of the raindrops to obtain velocity componont normal to the surface. Multiplication of this value with the amount of rain water in a unit volume of air will give the driving rain intensity on the surface. These values are the maximum driving rain intensities that will hit the building when the wind direction is perpendicular to the building element. If it is needed to find driving rain intensities when the wind is not perpendicular, these values should be multiplied by the cosine of the angle between the surface normal and wind direction.

This method can be used to find a " design value " for driving rain if the horizontal rain intensity and the wind velocity values are selected by taking into consideration the reoccurance period. An example to the application of the method is given in the appendix.

FIGURE 4 : Program in FORTRAN IV to calculate the horizontal component of raindrop velocity.

```
      K=1
100   READ(5,10) WG,DS,TV,GC,DW,DA,VA,TI,H,XI
10    FORMAT(F4.1,F8.5,2F5.2,F6.1,F6.3,E8.2,F4.1,F5.1,F3.0)
      K=K+1
      WRITE(6,56) DS,TV,GC
56    FORMAT(3D16.10)
      V=WG
      W=WG
      X=XI
      Z=H
5     DO 250 KJ=1,20
      R=DS*DA*ABS(V-W)/VA
      IF(R.LE.2.4)   GOTO11
      IF(R.LE.100.)  GOTO12
      IF(R.LE.800.)  GOTO 13
      IF(R.LE.1400.)  GOTO 14
      IF(R.LE.1800.)  GOTO15
      IF(R.LE.2100.)  GOTO16
      IF(R.LE.2700.)  GOTO17
      IF(R.LE.3000.)  GOTO18
      IF(R.LE.3200.)  GOTO19
      IF(R.LE.3500.)  GOTO 20
      GOTO 1001
80    FRM=-16.*VA*(V-W)/(DS*DS*DW)
      GOTO30
11    B=-6/EXP(R)
      GOTO25
12    B=0.29
      GOTO25
13    B=0.26
      GOTO25
14    B=0.30
      GOTO25
15     B=0.35
      GOTO25
16     B=0.40
      GOTO25
17    B=0.45
      GOTO25
18    B=0.50
      GOTO25
19    B=0.55
      GOTO25
20    B=0.60
25    C=24./R+6/(1+SQRT(R))+B
      FRM=-0.75*C*(V-W)*ABS(V-W)*DA/(DS*DW)
30    X=0.5*FRM*TI*TI+(V*TI)+X
      V=FRM*TI+V
      Z=-TV*TI+Z
      W=WG*(Z/H)**GC
      IF(Z.LT.3.0) GOTO310
      IF(KJ.EQ.1.OR.KJ.EQ.20)   GOTO222
      GOTO250
222   WRITE(6,301) X,V,Z,W
301   FORMAT(1H ,D15.9,D20.9,D19.9,D18.9)
250   CONTINUE
      GOTO5
310   IF(K.LT.39) GOTO 100
1001  STOP
      END
```

SPECIAL NOTATION USED IN THE PROGRAM

K	A parameter to record the results in every twenty computation
WG	Gradient wind velocity
DS	Predominant drop size
TV	Terminal velocity of the raindrop
GC	Exponent for the ground rougness
DW	Density of the raindrop
DA	Density of air
VA	Viscosity of air
TI	A short time increment
H	Gradient height
XI	Initial position of the raindrop along the x axis
V	Horizontal velocity component of the raindrop
W	Wind velocity
X	Position of the raindrop along the x axis
Z	Position of the raindrop along the z axis

NOTATION

a	: acceleration of the raindrop
C	: coefficient of drag
d	: diameter
dt	: a short time increment
F	: forces acting on the raindrop
F_D	: drag force on the raindrop
F_W	: weight of the raindrop
g	: acceleration due to gravity
H	: height above the ground
H_G	: gradient height
m	: mass of the raindrop
Re	: Reynolds number
S_M	: amount of rain water in a cubic meter of air
s	: power law exponent which depends on the roughness of the ground texture
Ş	: horizontal rain intensity (as measured by the meteorological stations)
$Ş_{düş}$	: driving rain intensity on vertical surface
u	: wind velocity
u_G	: wind velocity at gradient height, H_G
u_H	: wind velocity at height H
v	: velocity of the raindrop
v_t	: terminal velocity of the raindrop
X, Y, Z	: position of the raindrop along the x, y, z axes of the Cartesian coordinate system
ρ	: density
η	: viscosity
$-_d$	: of the raindrop
$-_e$	: predominant
$-_h$	: of the air
$-_i$	: initial
$-_x$	: along the x direction
$-_y$	: along the y direction
$-_z$	: along the z direction

REFERENCES

(1) LACY, R. E., Driving rain maps and the onslaught of rain on buildings. Building Research Current Papers, Research Series 54. Building Research Station, Ministry of Tecnology Watford, 1965.

(2) LACY, R. E., An index of driving rain. The Meteorological Magazine 91 (1080) July, 1962. pp. 177-184.

(3) SADAGASHVILI, G., Computinge exposure of wall joints in prefabricated buildings. Building Research and Practice Journal of CIB. September/October 1974 issue.

(4) SANDBERG, P. I., Driving rain distribution over an infinitely long, high building: Computerized calculations. Papers of CIB/RILEM Symposium on Moisture in Buildings. Rotterdam, 1974.

(5) RODGERS, G. C., POOTS, G., PAGE, J. K., PICKERING, W. M., Theoretical prediction of raindrop impaction on a slab type building. Building Science Pergamon Press 9 1974 pp. 181 - 190.

(6) GUNN, R., KINZER, D. G., The terminal velocity of fall for water droplets in stagnant air. Journal of Meteorology 6 August 1949. pp. 243-248.

(7) BEST, A. G., The size distribution of raindrops. Quarterly Journal of Royal Meteorological Society. 76 (16) 1950.

(8) DAVENPORT, A. G., The dependance of wind loads on meteorological parameters. International Research Seminar on Wind Effects on Buildings. Volume I. University of Toronto Press Toronto, 1967.

APPENDIX

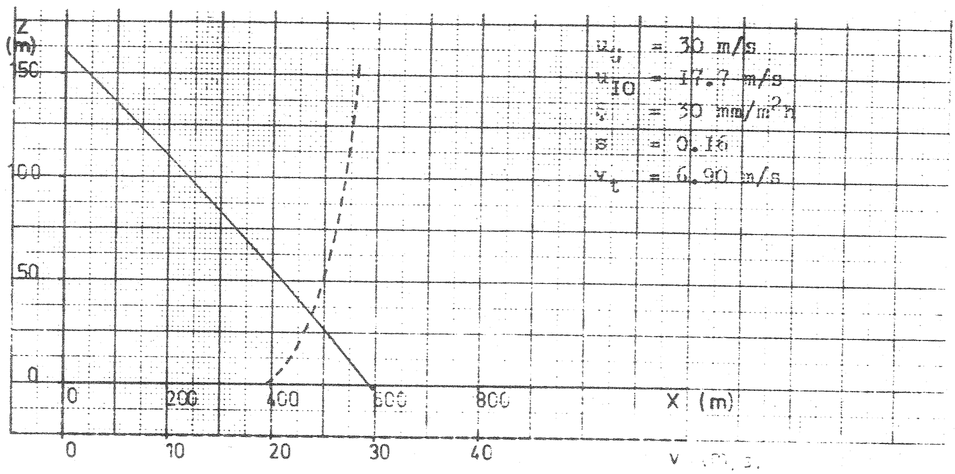
An Example : On a relatively flat part of Ankara, it was planned to construct a group of housing of three storeys height (10 meters) by the use of preformed wall components. What should be the design value of driving rain intensity in the design of the exterior wall joints ?

SELECT
Averaging time for rain and wind : I hour
Reoccurance time for the extreme rain intensity and the wind velocity values : 10 year

READ FROM THE METEROLOGICAL DATA
Horizontal rain intensity : 30 mm/m^2 h
Wind velocity at 10 m high : 14.4 m/s
(which are likely to be exceeded once in 10 years.)

READ FROM THE TABLES IN THE THESIS (or calculate)
Power law exponent for the ground roughness : 0.16
Predominant drop size for the given rain intensity : 0.0022 m.
Amount of rain water in a cubic meter of air : 1190.47 mm^3
Wind velocity at grandient height : 24.45 m/s

SELECT THE GRAPH



READ FROM THE GRAPH

Horizontal velocity component of the raindrops at the building height : 21.5 m/s