American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-7, Issue-5, pp-508-513
www.ajer.org
Research Paper Open Access

Effect on the Dynamic Behavior of the Coating Materials Selected In Airport Top Cover System

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ABSTRACT: In this study, arciform, steel structured airport terminal building has been designed; and to examine effect on dynamic behavior of the material, base shear, displacement and mode values of aluminum and tempered glass that are the coating materials and the construction weight have been compared to each other. Tempered glass of which unit weight is 4.36 % higher has had higher base shear values as 3.41 % in x direction, 5.33 % in y direction, and higher displacement values as 10.8 % in x direction, 7.96 % in y direction under the horizontal load of construction compared to the aluminum coating material. As a result, it has become clear again that aesthetics, function and materials selection are three most important design elements of a construction.
KEYWORDS Airport Terminal Buildings, Passing Long Span, Coating Materials, Covering System, Materials, Carrier System
Abbreviations
Sap2000 - Structural Analysis Program

Date of Submission: 16-05-2018 Date of acceptance: 31-05-2018

I INTRODUCTION

In Volkan Şaşmaz's "Havalimanı Terminallerinde Büyük Açıklık Geçme Sorununun Analizi" (Analysis of the Long Span Passing Problem in Airport Terminals) titled postgraduate thesis, how the spans in today's airport terminals have been passed and the terminal design concepts regulating the functional relations have been discussed. The structural features have been examined on the basis of carrier system and main material of the carrier system (Sasmaz, 2007).

In Sherif Mohamed Sabry Elattar's "Smart Structures and Material Technologies in Architecture Applications" titled article, beside the new technologies in the structure, effect on the construction of the materials has also been discussed (Elattar, 2013).

Edgar Sach's "Synthesis of Form, Structure and Material, Design for a Form-Optimized Lightweight Membrane Construction" titled article, it has been concluded that the combination of technological materials with the carrier systems of constructions will reveal smart solutions and new features (Sach, 2006).

Within the scope of Filiz Klassen's "Material Innovations" titled article, it has been concluded that besides selecting the construction materials and giving form in course of design, the architects must also know essence of the material chemically and formally (Klassen, 2003).

In D. Michelle Addington and Daniel L. Schodek's "Smart Materials and New Technologies for the Architecture and Design Professions" titled book, it has been concluded that due to the developments in materials and technologies, the elements restricting architectural design have been decreased (Addington, Schodek, 2005).

In Angus J Macdonald's "Structural Design for Architecture" titled book, it has been concluded the importance of design of the carrier system in the process of design, and that the materials selection must comply with the form and structural system. Moreover, design process of the structural system has been explained (Macdonald, 1998).

In Nenad Šekulera, Jelena Ivanović Šekularac, Jasna Čikić Tovarović's "Folded Structures in Modern Architecture" titled article, it has been concluded that using the carrier systems in conjunction with some different elements like folded plates eases the construction to be designed flexibly, and its production and installation processes with the advancing technology (Šekularac, Ivanović, Čikić, 2011).

In Ghazaleh Toutounchi Ghadim's "Geometry, Form and Structure Relationship in Blob, Liquid and Formless Architecture" titled thesis, due to the developments in construction technology, the construction restrictions have been exceeded in the scope of design. It shows that with dome, crust, grate and pneumatic systems, by the help of construction and technology, the formations of architectural forms require long spans (Ghadim, 2013).

Within the context of Mozaikçi B.'s "Mimarlıkta Forma Dayalı Algı Kavramı, Metal Malzemeler Üzerine Bir İnceleme" (Conception of Form-Based Perception in Architecture, An Examination On Metal Materials) titled article, while examining the matter of perception in constructions, in point of the construction form and the material used, its contribution to the perception system and the perception, figurativeness of the construction, and the image it exhibits have been discussed and interpreted. It has been questioned and interpreted how the constructions built with the metals used new in architectural applications such as steel, aluminum, titanium are perceived by examining them visually in scale of building from the outside as finished product. In addition, the technological values that are the main factor in development of the form and material within modernization that the last point arrived in architecture have been emphasized (Mozaikci, 2012).

In Louise Pedersen and Jonas Täljsten's "Structure As Architecture" titled thesis, it has been concluded that, within the context of interdisciplinary study, in other words during the engineer and architect understands the language of representation and expression, they will give better results in terms of the efficiency of structure; and more creatively designed constructions will appear (Pedersen, Täljsten, 2007).

In Kincl B. and Neidhardt V.'s "Structure of the New Zagreb Airport Passenger Terminal" titled article, in terminal buildings, to show passengers the direction they would go towards and make them reach within a limited period of time, the fact that the entirety should be perceived visually, making the hierarchy between places to be perceived with different sizes of volumes, and making the rhythm and flow of the movement to be directed have been emphasized. Moreover, it has also been emphasized that the waiting points must be in size so as to let the passengers gather, and the construction elements providing opportunity to grow and easiness to integrate with the materials developing in time should be selected (Kincl, Neidhardt, 2012).

II FORM, CARRIER SYSTEM AND MATERIAL IN ARCHITECTURE

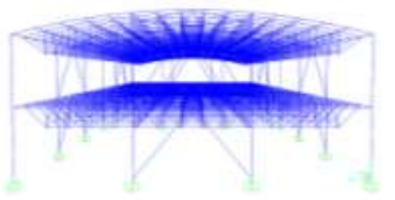
In architecture, constructing as high as possible, column-free and long-span areas or places and covering these areas definitely have been the most important seeking of all ages. It was seen that passing long spans could occur with the changes in selection of the form, material and carrier system; and in this context, various studies and application examples have begun to appear. In our day, the most successful examples of this seeking have been carried out with the frame systems. Construction of the frame systems has put the economical, fast, aesthetic and reliable solutions and the modern technology at service of the architecture. Accordingly, form and materials selection, effect on the architectural structure of this selection, how the frame systems are used as carrier, and their features have been explained in this chapter.

Architecture has been defined as the art of constructing the places required to ease people's life and for them to maintain actions such as shelter, fun, rest, and work by associating aesthetic and functional needs with the technical and executive obligations; in another definition, as the art and science of constructing and designing the constructions and physical environment. The architectural design process is a multi-staged process, and also many disciplines have to become a part of this (Guney, 2011). Form is one of the irreplaceable components of the architecture. The architectural design benefits from the material and technology when constituting the form. In time, new inventions in technology have affected development of the structures, and reflected to the architecture. Architectural structure has to be in total compliance with the form and place (Hasol, 2011). In architecture, transferring a certain idea is possible with the sketch drawings, through the form given with technical opportunities to the construction materials, and with an original carrier system. The forms of places are determined by depending on basically the function, materials and shapes of construction system. Abstract thought becomes concrete in the architectural construction by contribution of the material. In this context, it is seen that the material is a concrete factor and determinant in the form to be created and perceived, comprehended visually (Atac, 2006, Ching, 1996).

Architectural construction process has developed in parallel with the progress of mankind; and in configuration of the form that has different importance in different societies, it has showed development and change synchronously with the changes occurred in technical conditions, materials, architectural style of the day. In the second half of the 19^{th} century, metals such as aluminum, titanium and steel in particular were begun to be used commonly. Also with discovering the new metals, the increasing diversity of materials in architectural constructions has brought use of different architectural forms and surfaces with it (Atac, 2006). Metal materials are used for a variety of purposes in today's architecture, especially in the structural systems and frontage construction. While the steel that s one of these metals has been used as structural elements especially like column – beam; the metals like aluminum can also be used as plates in external wall coating. It causes different architectural perceptions and interpretations with regulating with different forms and different surfaces of these forms of the modern construction materials especially like steel and aluminum. With desire to create dynamic, different and undefined forms with use of metal materials, today visual quality of the constructions has increased and of course, visually perception of them has also increased at the same rate. The buildings transform into designs in sculptural forms with opportunities of metal materials (Atac, 2006).

III FIELD WORK

The model has been resolved with the arciform single-curved frame roof system. The terminal building designed has been constituted integrally in rectangular form and without dilation. Axis ranges of the system are 45 m at the basements, ground floor and top floor. Floor heights are kept fixed at each floor, and it is 9 m. It is a construction with 45 m x 90 m seating area, in 18.15 m- height, with 2 spans in x direction and 1 span in y direction, and with steel frame beamed roof system at the top. The frontage was covered with cladding elements. Trusses and purlins were placed in short line in the project. As material property; steel frame profiles St 52(S355JR) steel were selected. The system consists of two basements, one ground floor and first floor. In order to provide for the construction to have a light flexible design, and see better the setpoints (period, displacement, and base shear values) by analyzing statistically; steel carrier system has been selected. Flooring in the construction was made with the flooring system of in-situ concrete on steel decks. In-situ concrete flooring designed to work together with the steel beams shows rigid diaphragm behavior. To increase the robustness of the floor diaphragm, horizontal crossings were arranged on the flooring plane. Beam sizes; they are the tubular sections in 80 cm diameter in ground floors, and in 60 cm diameter in first floors. Truss ranges are every 3 m, in 3 m height. Purlins are every 1.5 m, passing 3 m span in the ground floor, every 3 m passing 3 m span in the 1st floor, and they are in 3 m height (Figure 1, Figure 2, Figure 3).

Fig. 1. Tree Dimensional Model of the Model in Sap2000 Program	**Fig. 2. Roof Model of the Model in Sap2000 Program**	**Fig. 3. Section of the Model**
		

When calculating the loads the construction will be exposed, it was generally benefited from the TS498, DBYYHY 2007, TS648, AISC-ASD 89 and IBC 2009 (Deflection Classes) and regulations and standards. Material Information: For the airport terminal building modeled with the response spectrum method, in columns and trusses tubular sections, in purlins and beams l profiles were used. Floorings have been designed as concrete floor on trapeze. In floors, crosses were placed, and it works as rigid diaphragm. What used in design of the system is St52 (S355JR) structural steel; its required features have been given in Table I. Loads considered in calculation: Coating loads have been transferred over the purlin element as uniformly distributed loads (Table II)

Coating Loads: In the examples of the long span passed construction examined, one of the most used coating materials is aluminum, and the other one is tempered glass. At the same time, the glass as coating material is frequently used in terms of its visuality, effect of transparency, and benefit from the natural light. Since in the first analysis, when as coating material aluminum was coated the total coating load was 80 kg/m2, and when it was coated with tempered glass the total coating load was 130 kg/m2; the coating load increases 62.5 %.

Table I Properties of the material used in the steel system for the airport terminal building modeled with the response spectrum method

Element	St52-S355JR
Type of Element	Frame
Modulus of Elasticity (GPa)	210.00
Tensile Strength (GPa)	510.00
Yield Point (GPa)	355.0
Shear Modulus (GPa)	80.769
Poisson's Ratio	0.30
Heat Expansion Coefficient	1.17x10
Unit Weight (KN/m^3)	76.97

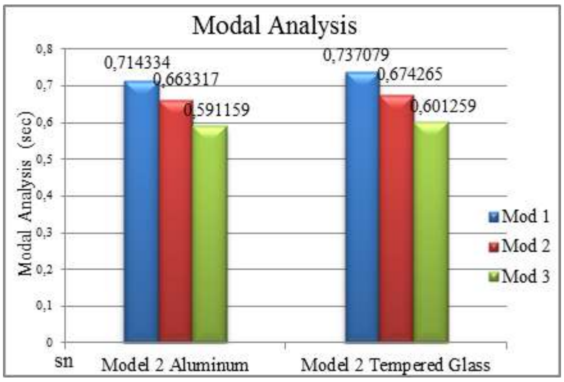
Table II Loads Considered in Calculation

Ground Floor:	1st Floor:	Frontage:
1. Dead Loads: a. Own Load: 7850 kg/m^3 (SW), b.Trapeze: 10 kg/m^2 (DL), c.Concrete: 375 kg/m^2 = 15 cm x 2500 kg/m^3 (DL), d.Leveling Screed: 72 kg/m^2 = 3 cm x 2400 kg/m^3 (DL), e.Marble: 81 kg/m^2 = 3 cm x 2700 kg/m^3 (DL), f. Installation: 50 kg/m^2 (DL) Total: own + 578 kg/m^2 ~ 600 kg/m^2 2. Moving Load : 500 kg/m^2 (LL)	1.Dead Loads: a. Own: 7850 kg/m^3 For aluminum; a. Top Coat: 25 kg/m^2 (Aluminum) b. Bottom Coat: 25 kg/m^2 (Aluminum) c.Installation: 30 kg/m^2 Total: own + 80 kg/m^2(Aluminum) 1.Service load: 100 kg/m^2 (Lr) 2.Snow load: 75 kg/m^2 (S)	a. Dead loads: Own: 7850 kg/m^3 b. Coating: 15+25 = 40 kg/m^2 c.Total: own + 40 kg/m^2

IV COMPARISON OF THE SELECTION OF ALUMINUM AND TEMPERED GLASS AS ARCIFORM COATING MATERIAL

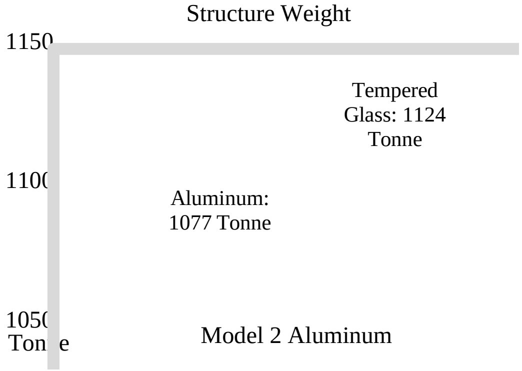
As seen in Table III, mode 1 value in hand of the arciform model with aluminum coating material has been taken as 0.714334 sec 100 %, and it has been 3.18 % lower than the model in hand with tempered glass coating material. Mode 2 value in hand of which with aluminum coating material has been taken as 0.663317 sec 100 %, and it has been 1.65 % lower than the model in hand with tempered glass coating material. Mode 3 value in hand of which with aluminum coating material has been taken as 0.591159 sec 100 %, and it has been 1.7 % lower than the model in hand with tempered glass coating material.

Table III Modal Analysis Values of the Aluminum and Tempered Glass Coated Steel Frame Roof Designs of the Model



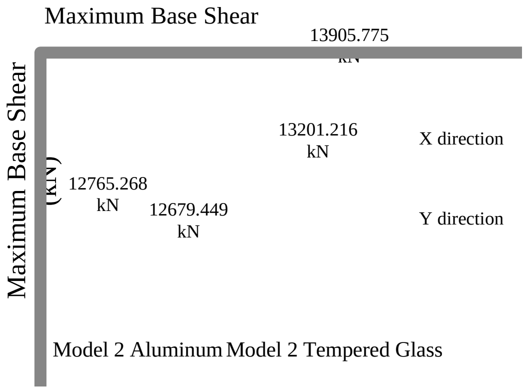
Unit weight of the aluminum selected as coating material has been taken as 80 kg/m2 and unit weight of tempered glass has been taken as 130 kg/m2. As seen in Table 4, aluminum coated total construction weight has been taken as 1077 Ton 100 %, and it has been 4.36 % lighter compared to the tempered glass coated model. The construction weight values of the aluminum and tempered glass coated steel frame roof designs of the model has been shown in Table IV.

Table IV Construction Weight Values of the Aluminum and Tempered Glass Coated Steel Frame Roof Designs of the Model



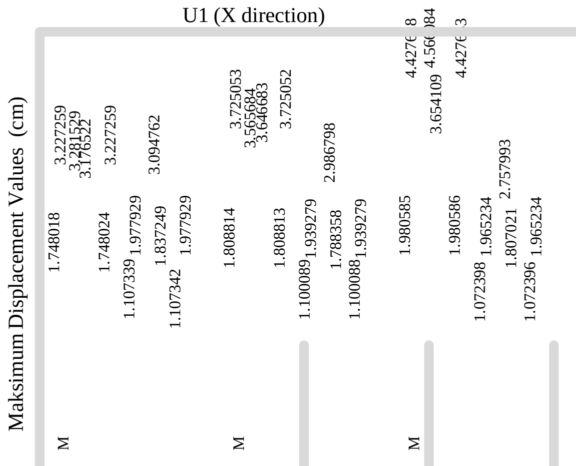
As seen in Table V, the maximum base shear value in hand of arciform with aluminum coating material in x direction has been taken as 12765.268 KN 100 %, and it has been 3.41 % lower than the model in hand with tempered glass coating material. The maximum base shear value in hand of which with aluminum coating material in y direction has been taken as 12679.449 KN 100 %, and it has been 5.33 % lower than the model in hand with tempered glass material.

Table V Comparison of the Maximum Base Shear Values for Aluminum and Tempered Glass Coated D1Z4



Maximum displacement values are at 2758th nodal point in x direction, and 16th nodal point in y direction. As seen Table VI, the maximum displacement value in hand of which with aluminum coating material in arciform in x direction is the 2758th nodal point of the selected nodal points, has been taken as 3.565684 cm 100 %, and it has been 10.8 % lower compared to the model in hand with tempered glass coating material. The maximum displacement value in hand of which with aluminum coating material in y direction has been taken as 3.651263 cm 100 %, and it has been 1.77 % lower compared to the model in hand with tempered glass coating material.

Table VI Comparison of the Maximum Displacement Values for Aluminum and Tempered Glass Coated D1Z4



V CONCLUSION

There is an indissoluble bond between architectural design, structure and material for all the constructions from the simplest construction to the long-span constructions. The most important goal of this study is to show that the criteria in material selection of a construction at the architectural stage are closely associated with the structural behavior of the product. In the scope of the study, the airport terminal building passing 45 meters of span, in rectangular form with linear concept has been designed. In order to pass 45 meters and design column-free places, the carrier system has been selected steel. Coating material of the designed arciform, aluminum and tempered glass coating material have been used. When compared the construction weight, modal analysis, maximum base shear and displacement values in the 1st degree seismic zone and Z4 ground class, response spectrum analysis; The maximum base shear value in hand of the arciform with aluminum coating material in x direction has been 3.41 % lower compared to the model in hand with tempered glass coating material. The maximum base shear value in hand of the arciform with aluminum coating material in y direction has been 5.33 % lower compared to the model in hand with tempered glass coating material. The maximum displacement value in hand of the arciform with aluminum coating material in x direction has been 10.8 % lower compared to the model in hand with tempered glass coating material. The maximum displacement value in hand of the arciform with aluminum coating material in y direction has been 7.96 % lower compared to the model in hand with tempered glass coating material. The mode 1 value in hand of the arciform with aluminum coating material has been 3.18 % lower compared to the model in hand with tempered glass coating material. The mode 2 value in hand of the arciform aluminum coating material has been 1.65 % lower compared to the model in hand with tempered glass coating material. The mode 3 value in hand of which with aluminum coating material has been 1.7 % lower compared to the model in hand with tempered glass coating material. When tempered glass has been used as coating material, the coating load in unit weight has been 130 kg/m2, increased 62.5 % compared to aluminum. Aluminum coated total construction weight of the arciform has been 4.36 % lighter compared to the tempered glass coated model. Effect on the construction weight of the materials selection, and thus the effect against the horizontal forces have been seen.

This study shows that the criteria in the form and materials selection of a construction at the architectural design stage are closely associated in changing structural behavior of the product. Critical and basic decisions such as building geometry, carrier system selection and materials selection to be made by the architect at the stage of sketch in the architectural design process have importance. Today’s modern architectural movements provide the material and form to come together as an indivisible whole by pushing the existing limits. As a result, it has become clear again that aesthetics, function and materials selection are three most important design elements of a construction. These three criteria are influenced by each other in the long-span place design criterion and change the construction behavior positively or negatively. However, in terms of knowing the features of the materials used and the carrier system, and understanding their limits; different designs will force the construction technology to go further.

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