LAND
SEA
AIR
SPACE

SOCIETY OF AUTOMOTIVE ENGINEERS, INC.
400 Commonwealth Drive, Warrendale, Pa. 15096

GMC Motorhome Body Construction

Lyn C. Hollis
General Motors Truck & Coach Div., General Motors Corp.

Society of Automotive Engineers

International Automotive Engineering
Congress and Exposition
Cobo Hall, Detroit
February 28 - March 4, 1977

770424

770424

GMC Motorhome Body Construction

Lyn C. Hollis
General Motors Truck & Coach Div., General Motors Corp.

ABSTRACT

This paper is intended to describe the body construction of the GMC Motorhome. This is done by following the evolution of the design from inception through styling, engineering and assembly. In this way, the reasoning behind the various design choices as well as the resultant design are discussed.

THE PURPOSE OF THIS PAPER is to describe the body construction utilized in a GMC Motorhome. By tracing the design from its inception, the parameters of the original concept and the design choices that were made throughout the evolution of the design will be discussed.

Any design is based, to a greater or lesser extent, on a compromise between aesthetic and functional factors. An underhood automotive bracket , for example, may exhibit very little of the aesthetic, while a sculpture may exhibit very little of the functional. Nevertheless, both factors are always present. In the case of the bracket, once all utilitarian objectives are met, the designer cannot resist laying lines that "look good". The sculpture is intended to be purely aesthetic and yet it must possess the practical features that make it possible for it to support its own weight, withstand the elements and so on. Obviously, the design of a motor home vehicle lies somewhere between these extremes, however, different motor homes in today's market place represent design approaches from either of these poles.

Many of the motor homes manufactured today consist of a rectangular or box-like motor home body mounted on a conventional truck chassis. This type of unit represents more the utilitarian approach to body design. These vehicles, which have formed the backbone of the motor home market for some time, were obviously designed with simplicity and maximization of available space as the foremost factors, with styling as a secondary consideration. That is to say, the vehicles were designed by the engineers with styling features added where they would not sacrifice the practical objectives of the design.

The GMC Motorhome was designed along entirely different lines. While in retrospect it is very difficult to differentiate which of several interrelated features came first, the basic approach was to give a stylist the general criteria and challenge the engineer with incorporating the functional aspects into the design.

Since the initial design approach is such an important factor in determining materials and processes, it was felt that a description of an existing motor home body construction could best be made by following the design from its inception. By understanding the general intent of the design, one can see the chain effect of one decision forcing another, and the constant compromises between the aesthetic and functional. To this end, this paper will describe the construction of a GMC Motorhome by following the design from its inception, explaining the design intents and how they led to the current construction.

DESIGN BACKGROUND

ORIGINAL DESIGN INTENT - The GMC Motorhome was originally conceived as but

Fig. 2 - The styling concept

approaches to designing the body, and thereby, describe the logic in the approach finally taken. This will be done by discussions of the selection of type of construction followed by descriptions of the body substructure, skins, and assembly. A brief description will also be made of body structural properties and structural analysis technique.

SELECTION OF CONSTRUCTION TYPE - The typical "box-type" motor home utilizes a wood-foam-aluminum skin composite structure. Such a construction is very weight efficient and quite simple. Since it is suited so well to flat surfaces, it is readily apparent how the construction method influenced the design concept. The GMC Motorhome is styled with virtually no flat surfaces and this, along with several other considerations, led to a different type of construction.

The more successful light weight structures, notably aircraft, have utilized skin stressing to optimize the strength-weight ratio. Monocoque-type construction (construction where the skin is the primary load carrying member) is generally regarded as the most weight efficient way to build an enclosed body. However, monocoque construction does restrict styling freedom and makes face lifting a major undertaking. In addition, assembly processes for monocoque-type designs tend to be somewhat difficult and exacting.

In balancing lightweight, structural requirements, and ease of assembly, a "quasi-

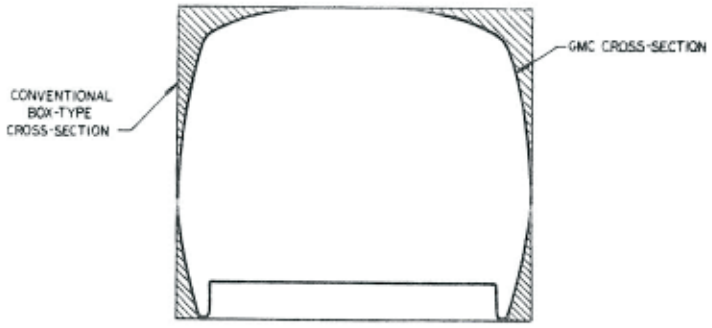

Fig. 3 - Body cross section comparison

monocoque" construction was selected. With this technique, composite skins are affixed to a cage framework, or sub-structure. The skins and sub-structure share the loads rather than the skins being the sole or primary load carrier as in a pure monocoque structure. (The method differs from a pure monocoque further since the body rests on a vehicle chassis).

BODY SUB-STRUCTURE - The GMC Motorhome can be broken down into three basic geometric units (see Figure 4). The front and rear units are composed entirely of compound curved surfaces, while the center section has a constant cross-section composed of several simple curved surfaces. The sub-structures, of course, had to provide the necessary structural requirements as well as the proper profile to support the skin and recreate the stylists' intent.

In the interest of light weight, corrosion-resistance and cost, aluminum was the logical material choice for the sub-structure members. AA6061-T4 was selected as the best alloy to allow extruding, post-forming, and welding.

The center body section is the basic structural unit. Its two sides and roof are built as sub-assemblies, then unitized in a fixture at which time the floor sub-structure is added. The side framing assemblies consist of three longitudinal beams and a series of upper and lower carlines (see Figure 5). The longitudinal beams contain channels that accept the formed carline ends as shown in the inset. With the exception of the end carlines which provide for the mating of the front and rear modules, the carlines may be located at any longitudinal position. This allows a great deal of flexibility in locating windows, doors, etc., for various applications or floor plans. Once the carlines have been located in their desired position, they are arc-welded in place.

The roof-framing assembly is quite similar (see Figure 6). It consists of two longitudinal beams with a series of curved, lateral roof bows and several longitudinal

"Z" section stringers. The formed ends of the roof bows fit within channels incorporated in the side beams and, as with the sides, all but the end roof bows may be positioned longitudinally as desired. In the Motorhome model, roof bows are placed on approximately 40" centers with four longitudinal stringers per bay. The stringers, too, may vary in number and location depending upon the existence of a roof top air conditioner, roof air vent, or some other specific structural requirement. Again, once the elements are properly located, they are welded in place.

The floor sub-structure is added after the roof and sides are joined. It consists basically of extruded crossmembers that nest within the lower side beams as shown in Figure 7. In the rear wheelhouse area, a sub-assembly is installed that is composed of two full-width crossmembers, two longitudinal beams, and three short crossmembers.

In the front and rear modules, the sub-structure is composed of both body panels and welded aluminum structure. In the rear, a "kick up" panel and formed box-beam extrusion provide the load path required by the rear body mounts (see Figure 8). In the front, a pair of aluminum stampings extend from the forward most carline of the center body section (see Figure 9). A pair of formed channels form the "nose" of the vehicle and a stamped toe-panel and sub-assembled driver's floor sub-structure is nested within the structure. On both the front and rear ends, the "vehicle skeleton" is actually completed by ribs that have been molded into the skin pieces.

BODY SKINS - As is the case in most vehicles, the body skins of the GMC Motorhome must perform several functions. The skins carry stress in sharing body loads and they must afford protection from the environment, etc. An obvious function is the cosmetic role the skins play; they are the media through which the styling concept is visually recreated. As part of their cosmetic function, the skins must have a good surface finish and accept paint well. In addition, the skin material must be compatible with the aluminum sub-structure. To meet the various parameters outlined, fiberglass and aluminum were selected as the skin materials.

As mentioned earlier, the front and rear sections are composed entirely of compound surfaces. To reproduce these shapes, molded, formed, or stamped panels are dictated. To provide an appropriate sub-structure in the front and rear sections would require a very elaborate welded aluminum framework, or inner

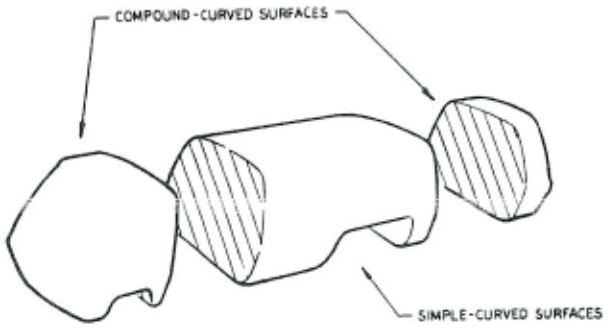

Fig. 4 - GMC Motorhome broken into three basic geometric units

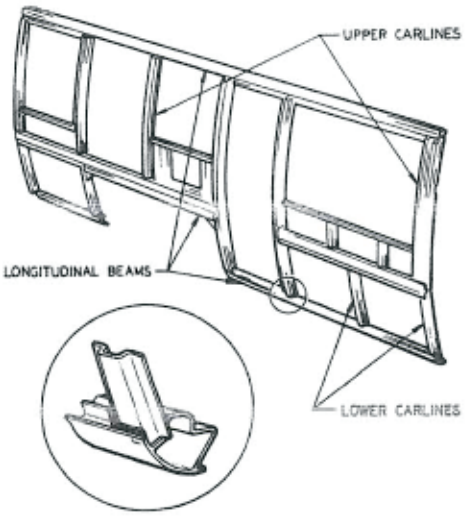

Fig. 5 - Side framing assembly

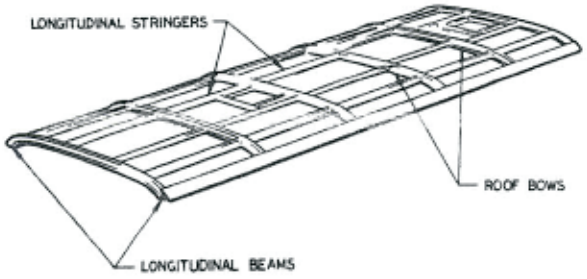

Fig. 6 - Roof framing assembly

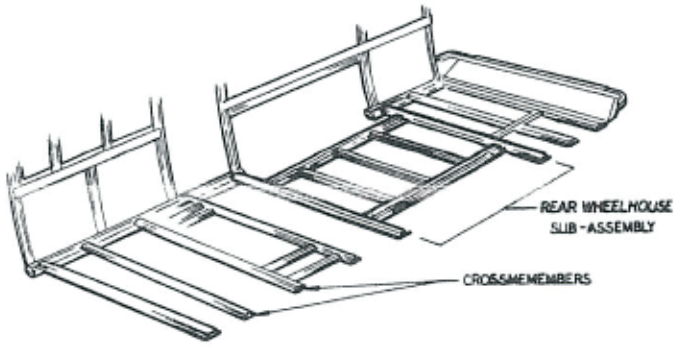

Fig. 7 - Floor substructure

and outer stampings if aluminum was to be the skin material. Utilizing sheet molding compound (SMC) made it possible to incorporate structural ribbing into the skin panels as shown in Figure 10 and, thereby, fulfill some of the requirements of the substructure. For this reason, SMC was used for all pieces of the front and rear skins as well as for the lower side panels (see Figure 11). The lower side panels were done in SMC because of the compounding factors of the wheel opening lips and access door louvers. In addition, the SMC panels provide for greater resiliency and repairability than aluminum for this rather subject-to-abuse area.

In the center section it was possible to reproduce the simple-curved surfaces by attaching a flat aluminum skin to the curved substructure. This was done for the upper side panels and roof as shown in Figure 12. The window and access door openings in the upper side panels are die-cut as dictated by the specific model or floor plan.

Because of the combination of aluminum and fiberglass, the attachment method of the skins was limited to mechanical fasteners (screws, rivets, etc.) and/or adhesives. It was highly desirable that the skin be smooth, which made the use of mechanical fasteners undesirable. For this reason, strong efforts were made to: utilize hidden fasteners; "trap" edges of skin panels in extrusions to make acceptable seams; and, where these were not possible, use only adhesive for the attachment. The result of these efforts is a body which is primarily adhesive-bonded, with mechanical fasteners (hidden or exposed) which act more or less as fixturing devices allowing the adhesive to cure. Selected for use in this application was a modified, two-part urethane structural adhesive. This afforded the added benefit of providing a body sealer as well as an adhesive.

BODY ASSEMBLY - Production designs are nearly always affected to some degree by the assembly process. How the body is to be assembled, and the order of assembly, will influence the design of joints, the location of fasteners, and so on. To better understand the GMC Motorhome construction, its general assembly procedure will be briefly discussed.

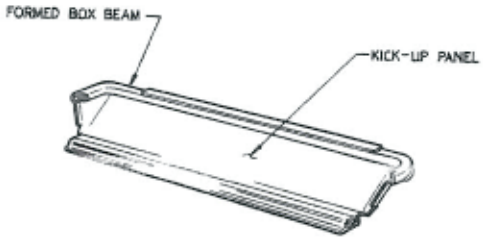

Fig. 8 - Rear structure

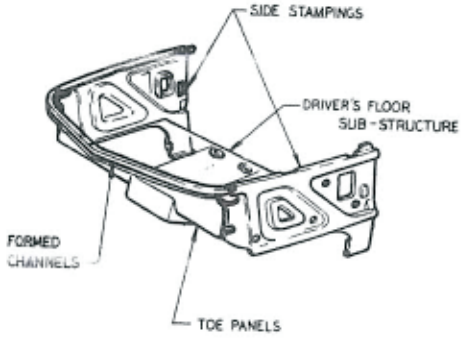

Fig. 9 - Front structure

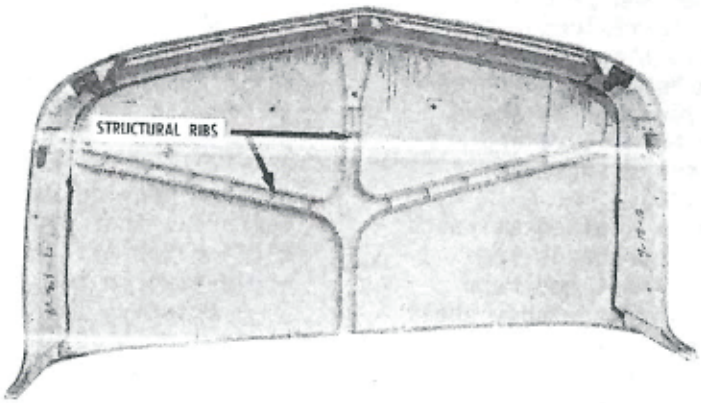

Fig. 10 - Structural ribbing in SMC front roof panel

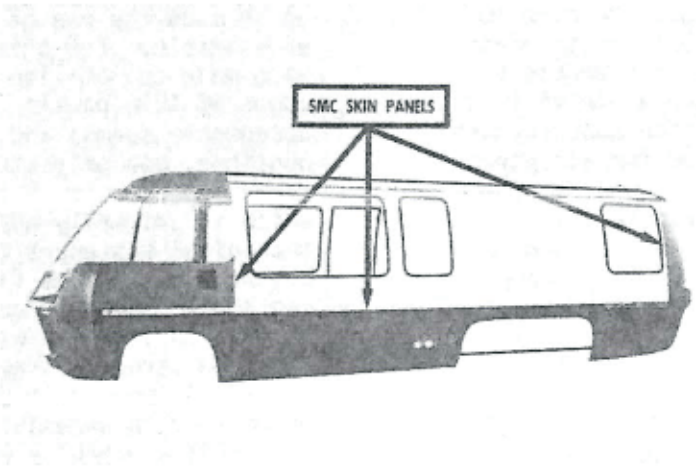

Fig. 11 - SMC skin panel utilization

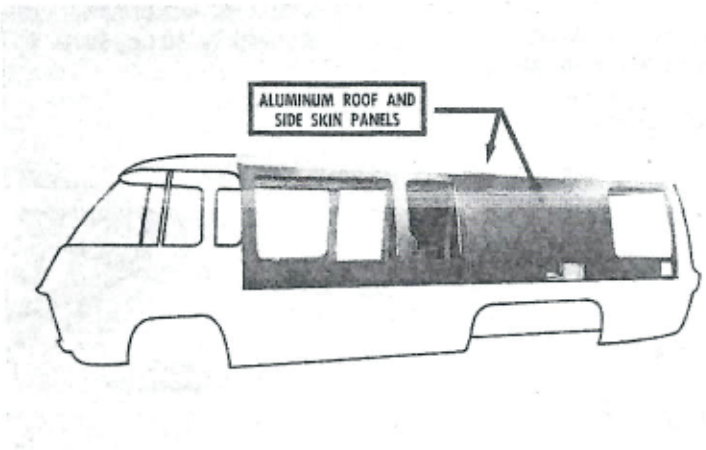

Fig. 12 - Aluminum skin panel utilization

The body is begun by welding the side and roof framing structures (Figure 13). The adhesion surfaces are sanded and primed, then the skins bonded and cured in fixtures as shown in Figure 14. The two sides and roof are joined in a fixture by bonding and riveting the mating extrusions together as shown in Figure 15. The floor substructure and front and rear substructure are then welded into the unit (Figure 15 & 16).

The unit progresses to a station at which underfloor insulation and floorboards are installed (Figure 17). The front and rear SMC parts are added to complete the body shell as shown in Figure 18. It should be noted that the large rear access door is removable to allow installation of interior components in subsequent operations as well as providing access for future repair operations (see Figure 19).

The body shell then proceeds for undercoating, paint preparation and painting. The entire interior of the vehicle is sprayed with urethane foam insulation. Other components are then installed prior to the body being dropped on the vehicle chassis.

BODY STRUCTURAL PROPERTIES AND ANALYSIS - Once the Motorhome was designed and tested, a finite-element computer model was developed to analyze stress levels and vehicle structural properties. Although the software package was completed after the design of the vehicle, the program provides a valuable tool for pointing out areas that could be enhanced and for predicting the effects that proposed changes would have on the entire structure.

Briefly, the computer program functions basically as follows. The body is modeled as a series of bar links and plate elements connected rigidly as depicted in Figure 20. By inputing loads at the proper points, the computer will analyze the load, deflection, and stress levels of each link and then show the cumulative effect in a graphic display. Figure 21, shows the magnified relative deflection experienced by a side structure

Page 7
Is Missing

Anyone that can assist in making this document complete, please forward the page to:
admin@gmcmi.com

Thank you.

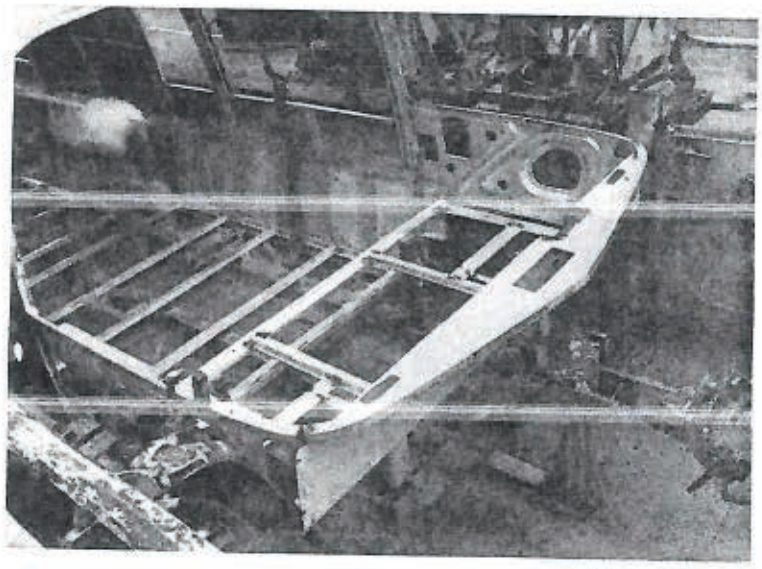

Fig. 16 - Front structure installation

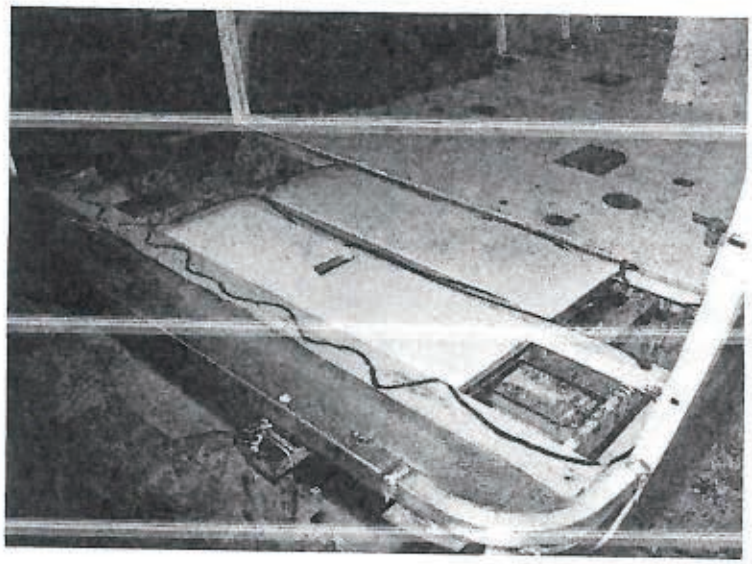

Fig. 17 - Floor insulation and floorboards

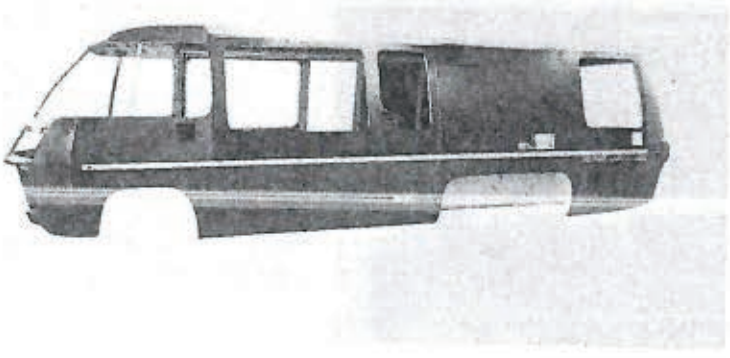

Fig. 18 - Completed body shell

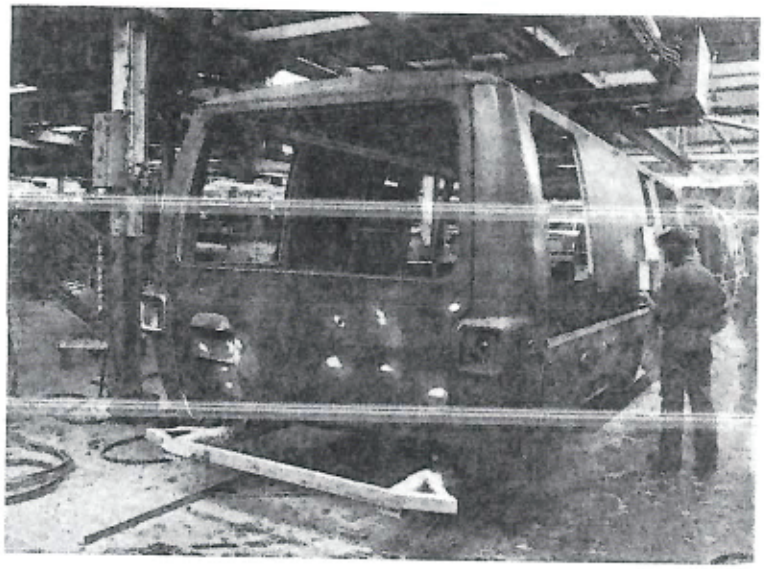

Fig. 19 - Rear access door

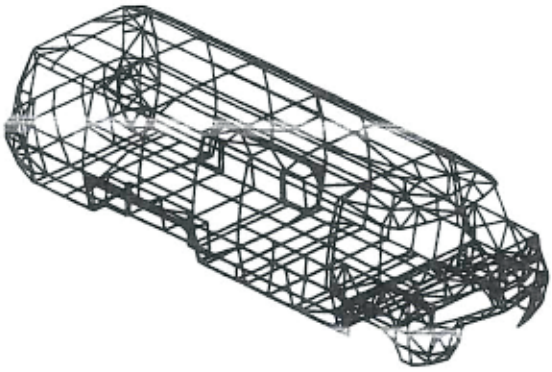

Fig. 20 - Finite element model graphic display

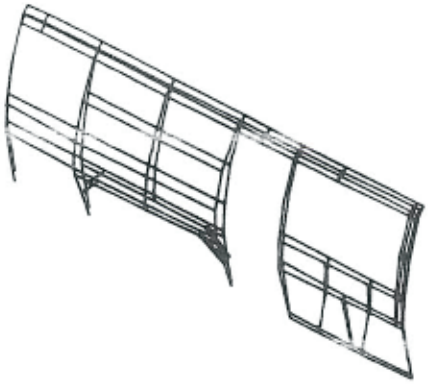

Fig. 21 - Relative deflection in side panel (computer graphic display)

when the vehicle undergoes a 3 g vertical loading. A similar graphic could be displayed by the computer for the entire body and frame if desired. The corresponding loads and stress levels for the particular loading mode could either be printed on the computer's graphic, as shown in the floor stress contour in Figure 22, or typed in a digital format on paper. In this way, any elements may be altered structurally on the model and the resulting effects on the body deflection and stress patterns predicted without having to actually undergo testing. Of course, major structural changes are subjected to actual tests to confirm the predicted results.

According to the mathematical analyses performed by the computer, the Motorhome frame/body has a torsional stiffness of approximately 14,000 ft-lb/deg between suspension locations. The "bending stiffness" (EI value) of the body structure is 6.4×10^9 lb-in^2, The fundamental vertical beaming frequency is estimated at 9.0 Hz.

SUMMARY

We have attempted to describe the construction of the GMC Motorhome body by discussing its evolution from conception through styling, engineering, and assembly. By providing Styling with general criteria and allowing them significant latitude, the design was approached more from the "aesthetic pole" rather than from the functional. That is, the vehicle was styled with aesthetics and aerodynamics in mind with the functional requirements engineered into the styling concept.

The styling, as well as the desired parameters of light weight and corrosion--resistance, focused the choices of material and process available to re-create the design. The result is a quasi-monocoque body construction with a welded aluminum substructure, and molded SMC fiberglass and aluminum skins. The skins are adhesive-bonded to the substructure with mechanical fasteners used very sparingly more as fixturing devices. The framework de-

sign allows a great deal of flexibility of carline locations, making it relatively easy to adapt the vehicle to different floor plans and multiple applications. Figure 23, shows the current GMC Motorhome and Transmode vehicles. At present, GMC Transmode vehicles are being used as small busses, emergency rescue vehicles, portable laboratories, moving offices, demonstration facilities, portable health-care units, and many other applications, all with the same basic body design.

Even though the design is well-established, work is now underway to make the Motorhome body lighter and more aerodynamically efficient Future GMC Motorhomes will utilize more exotic construction materials and techniques with efforts being directed at a purer monocoque design.

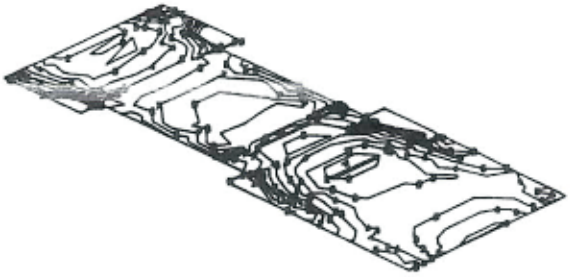

Fig. 22 - Floor stress contour (computer graphic display)

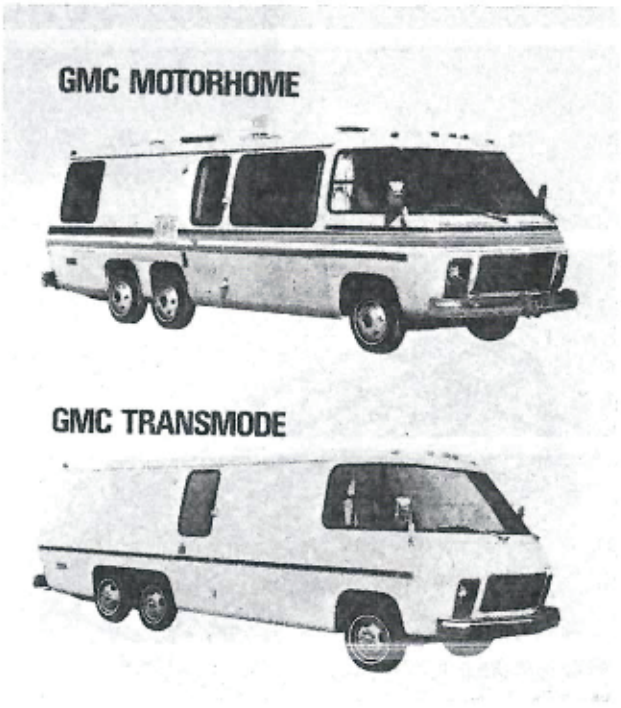

Fig. 23 - GMC Transmode and Motorhome

Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA 15096

12 page booklet.

Printed in U.S.A.