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TECHNICAL REPORT NO. 226

AN EVALUATION OF THE RUST CONDITION OF TRUCK, 1/4 TON: M151 SERIES

PETER B. FERRARA
RAYMOND BELL
ROBERT E. MIODUSKI

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US ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY
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The determination of the extent of rust occurring with the 1/4 ton truck fleet has been made. As part of this determination, an evaluation of rust as a function of vehicle age, location and usage status was also carried out. Also presented are procedures for repairing severely rusted sections of the truck. Further, recommendations are presented for reducing the incidence of rust and for providing the field with a means of repairing severly rusted parts of a truck.

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AN EVALUATION OF THE RUST CONDITION OF TRUCK, 1/4 TON: M151 SERIES

1. SUMMARY

1.1 Problem.

During the conduct of the Vehicle Useful Life Study for Truck, Utility; 1/4 ton, 4x4, M151A1, some concern was expressed that the fleet of 1/4 ton trucks was experiencing a significant rust problem.

1.2 Objective.

The objective of this effort was to determine the extent of the rust problem with the 1/4 ton fleet and what corrective actions could be taken to reduce this problem.

1.3 Approach.

The determination of the extent of rust occurring with the 1/4 ton truck fleet was made by conducting a random inspection of vehicles located at several CONUS and OCONUS Army installations. During this inspection, each of the six major vehicle areas (frame/cross member, front floor, rear floor, front fender, rear fender, and hood/body) were assigned a rust classification (from very slight to very heavy) and an evaluation of the rust condition on an overall basis and as a function of vehicle age, location and usage status was carried out.

1.4 Discussion.

The study was based on an inspection and evaluation of the rusting condition of 722 1/4 ton trucks. Of these vehicles, 319 were in an operational unit, 108 were in pre-positioned stock, 226 were at property disposal locations and 69 were in salvage yards. The data were collected from seven different Army installations including the Maryland National Guard and 8th Army, Europe from December 1975 through June 1976. Most of the vehicles included in the study varied in age up to 12 years (the current life of the truck). Some vehicles inspected, however, were actually beyond the current life expectancy for the truck.

1.5 Conclusions.

Based on the results of this study, rusting was found to be a serious problem with the M151 Series 1/4 ton truck. Approximately 25% of the trucks had sufficient rust so as to question the structural integrity of the unit/body area, i.e., the frame/cross members that supported the power train. In studying this rust problem, it was found that the severity of rust appears to be more related to location environment than to age. For example, vehicles at locations such as Europe (excluding pre-positioned stocks) and Fts. Belvoir and Meade showed generally more severe rust than vehicles at Ft. Hood while when studying severity of rust as a function of age no worsening of rust with increasing age was found. This is not to imply that age has no relationship to the rust process only that vehicle location seems to be a more significant factor in the rusting process. This rust problem, however, was found to be correctable. In those cases in which the rust had developed to the degree where the truck's structural integrity was of questionable strength (i.e. in the frame/cross member area), a fix costing approximately $100-300 could be produced which would provide proper support to the power train so that the truck could continue to be utilized. In other areas of the vehicle (floor, fender, hood, body) where rust was found to be very heavy, steel-plating (overlaying) of these areas was found to be an appropriate corrective procedure.

1.6 Recommendations.

To reduce the incidence of rust and to provide the field a means of repairing rusted out sections of the truck, the following procedures are recommended:

(1) TM-9-2320-218-34, Chapter 17, should be expanded to include methods of repairing rusted-out areas of the vehicle unit body, particularly the frame/cross members section of the vehicle.

(2) Drain holes should be enlarged and relocated so as to assure full drainage of water from the front floor area, regardless of the attitude of the vehicle when parked (See Photograph 1.1).

(3) Emphasis should be placed on periodic cleaning of all drain holes in the unit body, perhaps during a scheduled maintenance action.

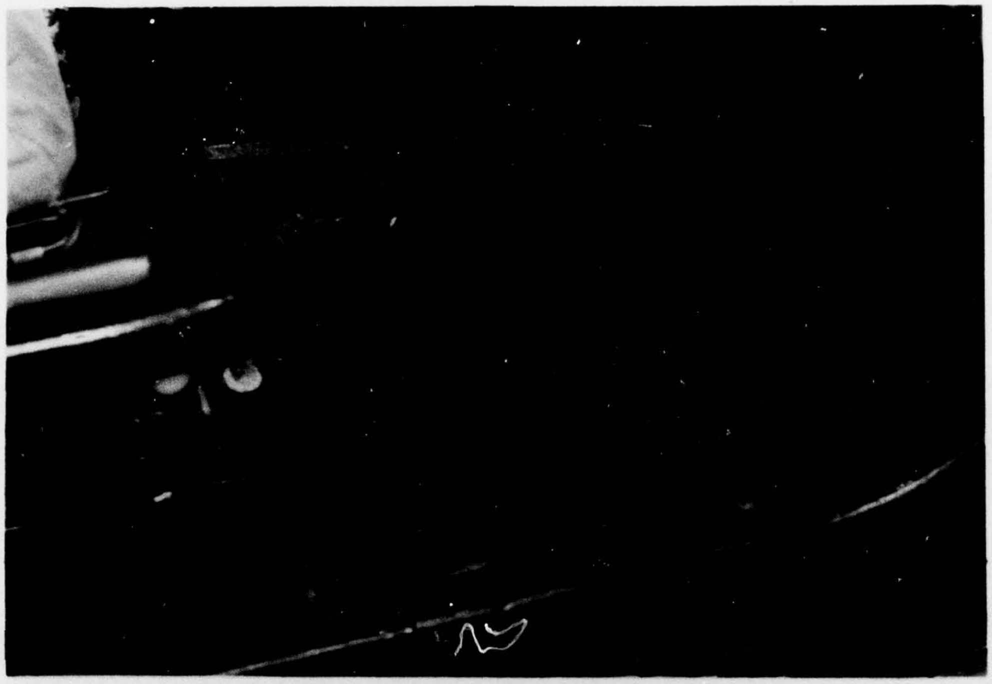
(4) Rust inhibitors and/or undercoating should be applied to the vehicles, particularly in locations where the vehicles are subject to a salty environment (road or ocean salt) when it is determined to be cost effective.

2. INTRODUCTION

During the conduct of the Vehicle Useful Life Study for the M151A1/A2 1/4 ton truck, some concern was expressed about extending the life of the 1/4 ton truck because of a possible growing rust problem. Initial review of this problem, however, indicated that the rusting that was occurring with these vehicles was more related to usage environment (e.g. salty atmosphere) than vehicle age and thus rust was not considered to be detrimental from the standpoint of extending vehicle life (8 to 12 years). However, as a result of the concern about rust and its affect on the fleet, this Activity initiated an in-house study of the 1/4 ton vehicle fleet to determine the severity of the rust and what corrective procedures were available for reducing this problem.

3. DATA SOURCE

In the conduct of the study to evaluate the severity of the 1/4



Photograph 1.1 - Front Floor Pans Showing Accumulation of Water.

ton truck rust problem, AMSAA visited seven different Army sites (Maryland National Guard, Baltimore, MD; Ft. Meade, MD; Ft. Belvoir, VA; Ft. Bragg, NC; Ft. Hood, TX; 8th Army, Europe; and Aberdeen Proving Ground, MD) to determine the rusting condition that was existing in these areas. It should be mentioned that the visit to some of these sites (e.g. 8th Army, Europe) was conducted in conjunction with other AMSAA business and thus did not require special trips to these installations.

In the survey of 1/4 ton trucks at these sites, the following trucks were examined: M151, M151A1, M151A1C, M825 and M817 vehicles, all of which have identical undercarriage design - principally in the frame/cross member area of the unit body. In the survey no attempt was made to examine all 1/4 ton trucks at these sites rather trucks selected at random were examined. As a result, 722 trucks were examined. These varied in usage status from operational (in general use in the field), pre-positioned stock, property disposal, to some that were classified as scrap (salvage). Of the total number examined, 319 (44%) were in operational use, 108 (15%) were in pre-positioned stock, 226 (31%) were in property disposal and 69 (10%) were in salvage. Table 3.1 shows the distribution of those vehicles surveyed by location and usage status while Table 3.2 shows the average age and mileage summary of the surveyed vehicles.

4. RUST CLASSIFICATION

To assure that there was a consistent method for determining the rust condition of vehicles examined in the survey, a standard defining various levels of rust was established. In arriving at this standard, input was obtained from various Army mechanics such as metal workers (MOS 44 B10) and metal worker supervisors (MOS 44 B3H) as well as comparable civilian mechanics. In classifying the rust condition of the trucks, the trucks were graded from very slight rust to very heavy rust (see photographs 4.1 through 4.5 for examples of the degree of rust associated with an assigned rust condition). During the classification of vehicles according to rust condition, each major vehicle area was assigned a rust condition. Thus, the frame/cross member(s) (which support the power train or suspension system), the front floor (including rocker panel area), the rear floor (including tail plate area), the front fenders (underside), the rear fenders and the hood and remaining body areas all were evaluated separately. During the classification of the various major parts of the vehicles according to rust condition, it was observed that some vehicles had areas that had been steel-plated. This steel-plating had apparently occurred because the vehicles had exhibited very severe rust on these areas and in order to correct this situation, the rusted areas were repaired by capping them with a steel plate and/or a pre-formed cap. Thus, in the classification of vehicles according to rust, a separate category for steel-plating was established. It is noted that during the survey all inspections were made by the same individual(s) to assure consistent grading of the rust conditions from vehicle to vehicle and location to location.

TABLE 3.1 DISTRIBUTION OF 1/4 TON TRUCKS SURVEYED

Location	Total Number Surveyed	Usage Status			
		Operational	Pre-Positioned Stock	Property Disposal	Salvage
APG, MD	23	6	0	0	17
8th Army, Europe	156	44	108	0	4
Ft. Bragg, NC	202	0	0	202	0
Ft. Hood, TX	95	47	0	0	48
Ft. Belvoir, VA	24	24	0	0	0
MD National Guard	105	105	0	0	0
Ft. Meade, MD	117	93	0	24	0
TOTAL	722	319	108	226	69

TABLE 3.2 AGE AND MILEAGE SUMMARY OF 1/4 TON TRUCKS INCLUDED IN STUDY

BY LOCATION

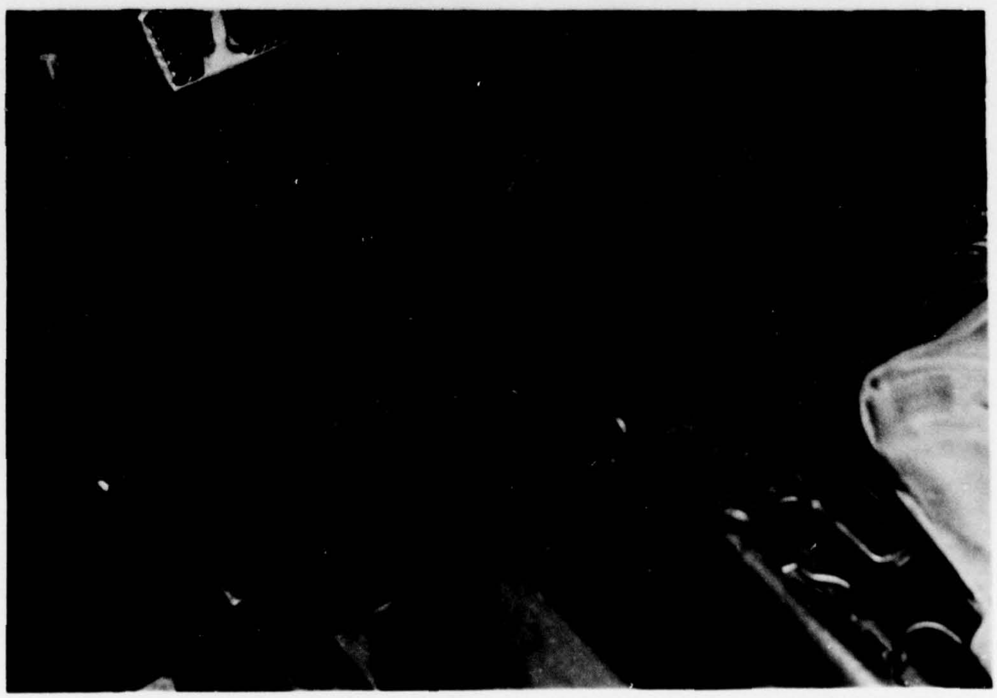
	Mileage				Age (Yr.)			
Location	No. Trucks Cons.	Min.	Max.	Avg.	No. Trucks Cons.	Min.	Max.	Avg.
APG, MD	21	1177	47912	17984	22	7.4	12.3	9.8
8th Army, Europe	154	4*	50140	14525	152	6.9	14.5	9.5
Ft. Bragg, NC	201	9*	98043	28128	191	6.4	13.1	9.8
Ft. Hood, TX	94	392	91103	25230	93	5.3	14.0	10.0
Ft. Belvoir, VA	24	2145	52708	20442	24	8.4	10.0	9.1
MD National Guard	105	956	26882	16538	105	8.1	10.3	9.2
Ft. Meade, MD	117	2116	66000	21827	112	6.5	10.5	9.0
Overall	716**	4*	98043	21537	699**	5.3	14.0	9.5

BY USAGE STATUS

	Mileage				Age (Yr.)			
Usage Status	No. Trucks Cons.	Min.	Max.	Avg.	No. Trucks Cons.	Min.	Max.	Avg.
Operational	315	9*	98043	21159	312	5.3	14.3	9.1
Pre-Positioned Stock	108	4*	34459	6488	105	7.1	14.5	9.9
Property Disposal	225	2116	66000	27519	214	7.8	10.6	9.8
Salvage	68	1514	91103	27332	68	7.7	14.1	10.3
Overall	716*	4*	98043	21537	699*	5.3	14.5	9.5

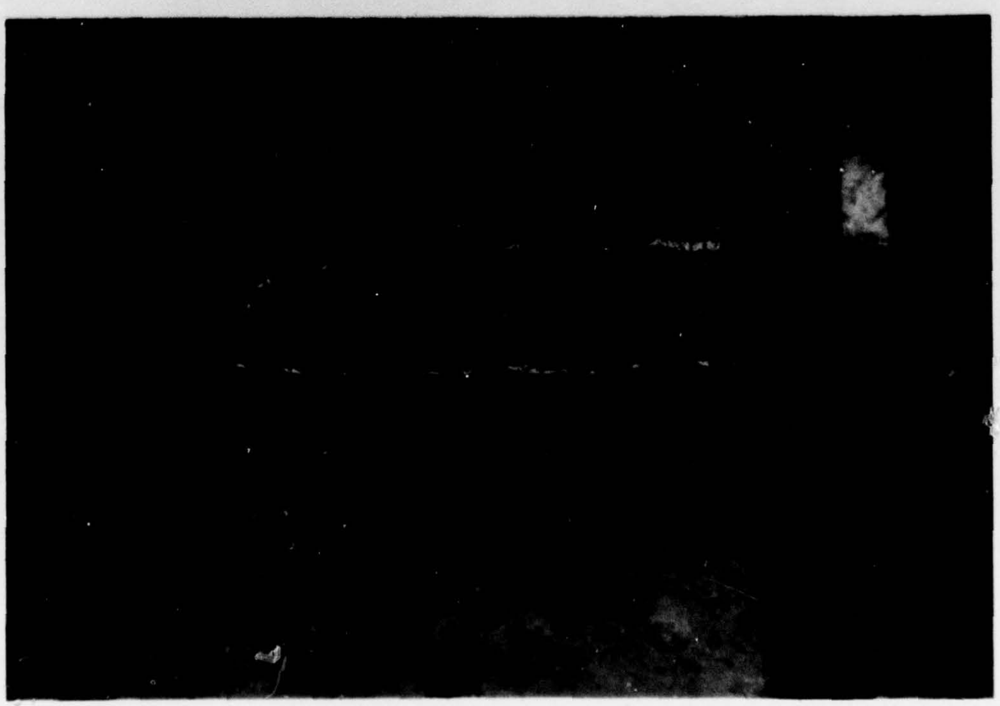
*Low mileage indication may have been due to odometer change.
**Of the 722 trucks surveyed, no mileage data were available for 6 trucks while no age data were available for 23 trucks.

Photograph 4.1 - Typical Example of Very Slight Rust Condition.

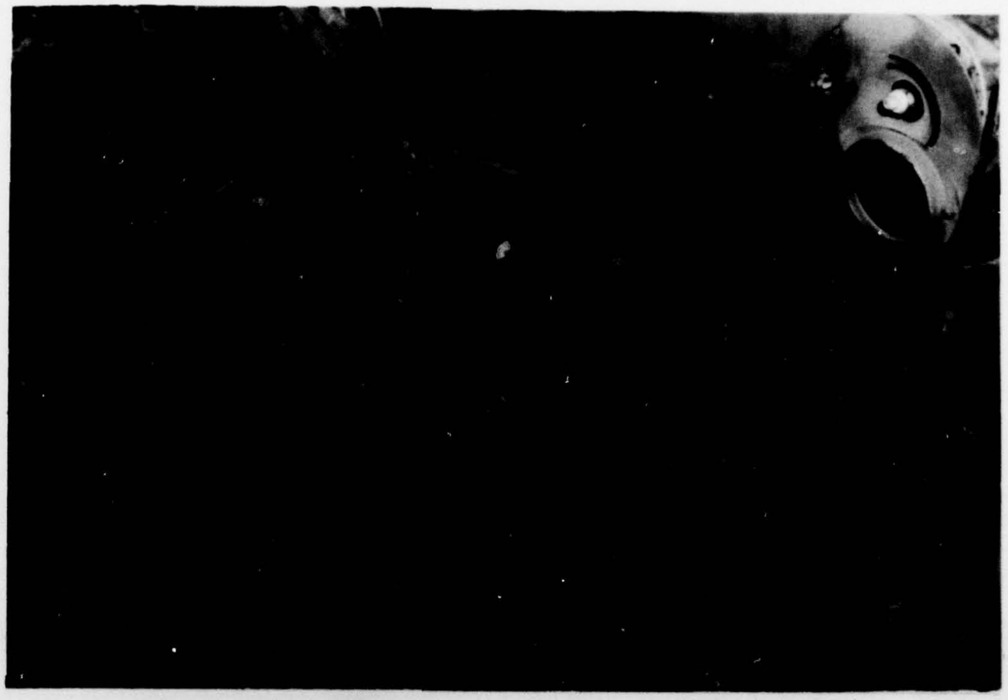


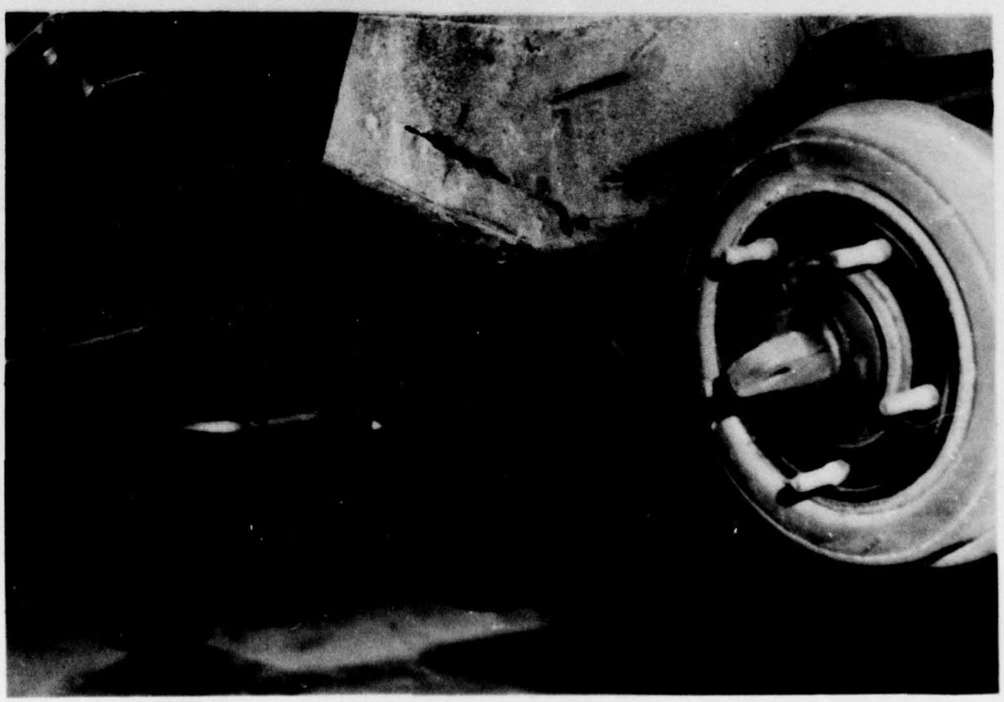
Photograph 4.2 - Typical Example of Slight Rust Condition.

Photograph 4.3 - Typical Example of Moderate Rust Condition.



Photograph 4.4 - Typical Example of Heavy Rust Condition.





Photograph 4.5 - Typical Examples of Very Heavy Rust Condition.

5. RUST EVALUATION

In evaluating the extent of rust with the 1/4 ton fleet, the 722 vehicles surveyed were studied from the following viewpoints: (1) overall fleet condition, (2) rust versus vehicle age, (3) rust versus usage status (i.e., operational, pre-positioned stock, salvage or in property disposal), and (4) rust versus vehicle location.

5.1 Overall Fleet Condition.

As indicated above, in determining the extent of rust with the 1/4 ton fleet, each vehicle surveyed was assigned a rust condition from very slight to very heavy. In addition, the rust classification assigned was assigned separately for each of the six major areas (frame/cross members, front floor, etc.) of the truck. In dividing the vehicles into the six major areas, it should be noted that the frame/cross members are the most important parts of the truck unit body because they provide support to the power train components. Severe rust in these areas could threaten the structural integrity of the vehicle.

Shown in Table 5.1 is a summary of the rust conditions (by truck area) of the 722 vehicles included in the study. As indicated in this table, approximately 25% of trucks had heavy or worse rust in both the frame/cross member and front floor areas, the two most important areas of the truck. The front floor is a vital area not only because the driver places his feet there but because the vehicle controls (gas pedal, clutch, etc.) are located there. Noted in Table 5.1 is a rust condition entitled "steel-plated." This condition, as noted above, implies a vehicle which had such severe rust that the rusted portion of the vehicle had to be covered over with a steel plate. It should be noted that only about 5% of the surveyed trucks had been found to have steel-plating in some section of the truck. Thus, in categorizing the trucks into an overall rust condition (moderate or less vs. heavy or worse), the steel-plated trucks were included in the heavy or worse category since they had experienced severe rust prior to steel-plating.

5.2 Rust Versus Vehicle Age.

In determining if the degree of rust was associated with vehicle age, all six vehicle areas were studied separately to determine if increasing age was resulting in a significantly higher frequency of vehicles with a worsening rust condition. In this analysis, the vehicles were grouped into the following age categories: less than 8 years, 8 to 9 years, 9 to 10 years, 10 to 11 years, 11 to 12 years and greater than 12 years. The vehicles were grouped into these categories because of sample size and because there was particular interest in determining if the vehicles exhibited increased rust as they progressed in age from 8 to 12 years (the recent life extension).

TABLE 5.1 SUMMARY OF RUST CONDITION FOR 1/4 TON TRUCKS

Rust Condition		Truck Area											
		Frame/Cross Members		Front Floor		Rear Floor		Front Fenders		Rear Fenders		Hood/ Body	
		No. Trucks	%	No. Trucks	%	No. Trucks	%	No. Trucks	%	No. Trucks	%	No. Trucks	%
Moderate or Less	Very Slight	75	10.4	105	14.5	126	17.5	121	16.8	136	18.9	102	14.2
	Slight	225	31.3	184	25.5	224	31.0	373	51.7	249	34.6	288	40.2
	Moderate	238	33.1	247	34.2	292	40.4	175	24.2	240	33.4	214	29.8
	Overall	538	74.8	536	74.2	642	88.9	669	92.7	625	86.9	604	84.2
Heavy or Worse	Heavy	82	11.4	77	10.7	46	6.4	32	4.4	71	9.9	48	6.7
	Very Heavy	65	9.0	54	7.5	19	2.6	9	1.2	21	2.9	25	3.5
	Steel-Plated	34	4.7	55	7.6	15	2.1	12	1.7	2	0.3	40	5.6
	Overall	181	25.2	186	25.8	80	11.1	53	7.3	94	13.1	113	15.8

In the analysis of the six vehicle body areas as a function of age, a chi-square (X^2) test (See Appendix for detailed discussion of test method) was carried out to determine if rust condition was independent of vehicle age. As an example of this type statistical analysis, the analysis for the frame/cross members area is presented. The data utilized in this analysis are summarized as follows:

Rust Condition	Age (yrs.) <8		8-9		9-10		10-11		11-12		>12		Total f_i
	f_i	F_i	f_i	F_i	f_i	F_i	f_i	F_i	f_i	F_i	f_i	F_i	
Very Slight	19	9.9	5	12.9	31	27.3	8	13.6	6	7.0	5	3.3	74
Slight	31	29.6	38	38.5	74	81.9	45	40.8	21	21.0	13	10.2	222
Moderate	19	30.8	43	40.1	82	85.2	51	42.4	26	21.9	10	10.6	231
Heavy	13	10.1	15	13.2	27	28.0	13	14.0	6	7.2	2	3.5	76
Very Heavy	11	8.0	9	10.4	23	22.1	10	11.0	5	5.7	2	2.8	70
Steel-Plated	0	4.5	11	5.9	20	12.5	1	6.2	2	3.2	0	1.7	34
Total f_i	93	-	121	-	257	-	128	-	66	-	32	-	697

As indicated in this table, the f_i values are the observed frequencies and the F_i values are the theoretical or expected frequencies. Utilizing these frequencies in a X^2 test for independence, the following analysis is presented:

$$X^2 = \sum^{36} \frac{(f_i - F_i)^2}{F_i} = 50.1$$

with 25 degrees of freedom. For the .05 level of significance,

$$X^2_{.95}(25) = 37.7$$

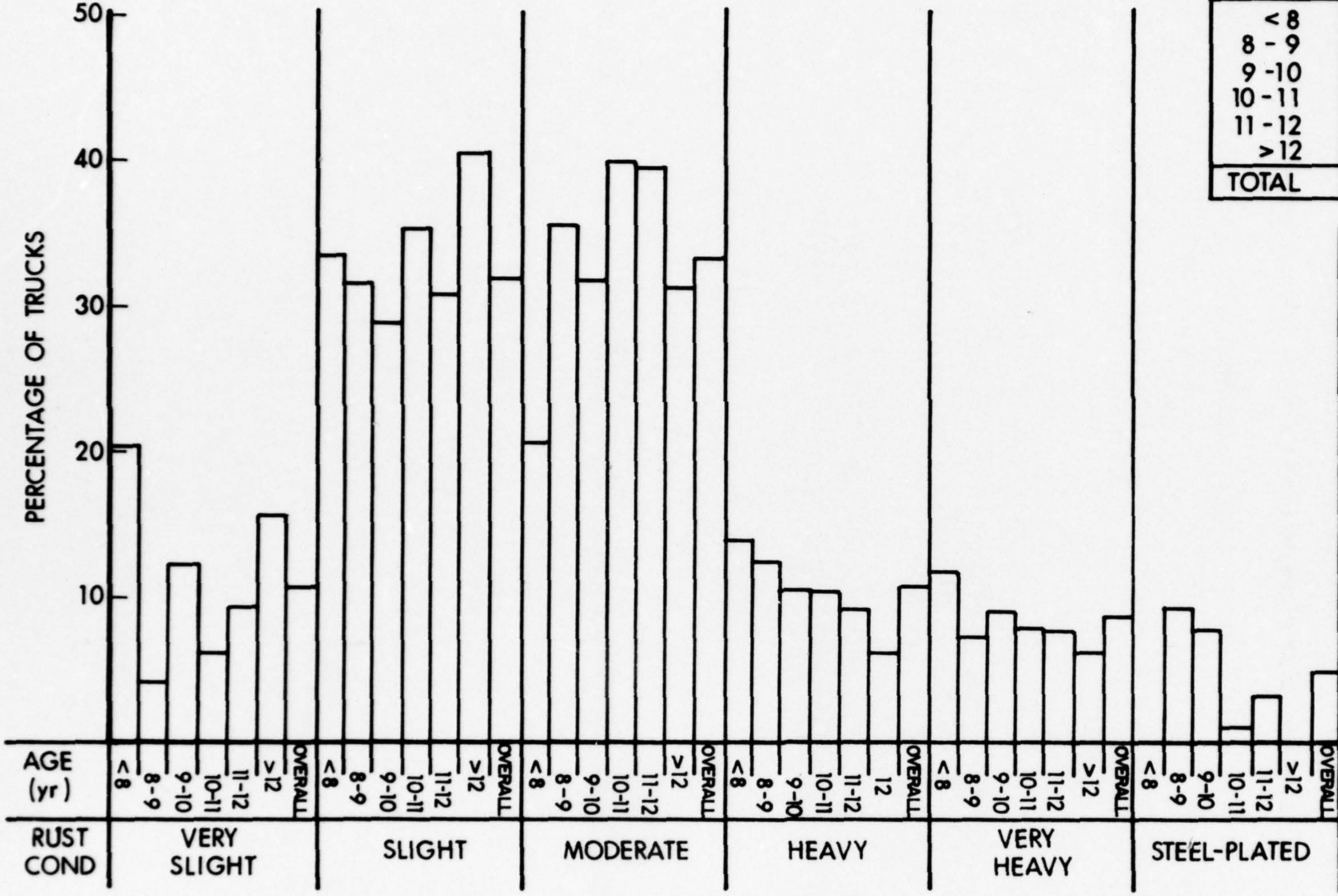
Since the computed X^2 value (50.1) is greater than the critical value at the .05 level of significance, the null hypothesis of independence of the rust condition and vehicle age was rejected indicating that each rust condition did not have the same proportion of vehicles in the six age categories. For example, in the frame/cross members heavy rust category, the percent of heavy rust varies from 14% of the vehicles in the <8 year age category downwards to 6% in the >12 year age category. It is pointed out that although a difference was found between ages, the rust condition was not increasing with age. This indicates that the amount of rust is primarily due to factors other than age such as perhaps the conditions in the area where the vehicle is being used (e.g. salty environment). Similar results were obtained for the analysis of the other five vehicle areas, i.e., significant differences were found between ages in the various rust conditions but there was no indication that the severity of rust was increasing primarily as a function of aging (see Figures 5.1 thru 5.6 for a plot of the rust condition by age of the six vehicle areas studied).

5.3 Rust Versus Usage Status.

As noted, vehicles included in the study were classified into four different usage status categories. These include: (1) vehicles in general operational use in the field (319 or 44% of trucks surveyed), (2) vehicles in pre-positioned stock in Europe (108 or 15% of the vehicle surveyed), (3) vehicles in property disposal (226 or 31% of the vehicles) and (4) vehicles in the salvage yard (69 or 10% of the vehicles).

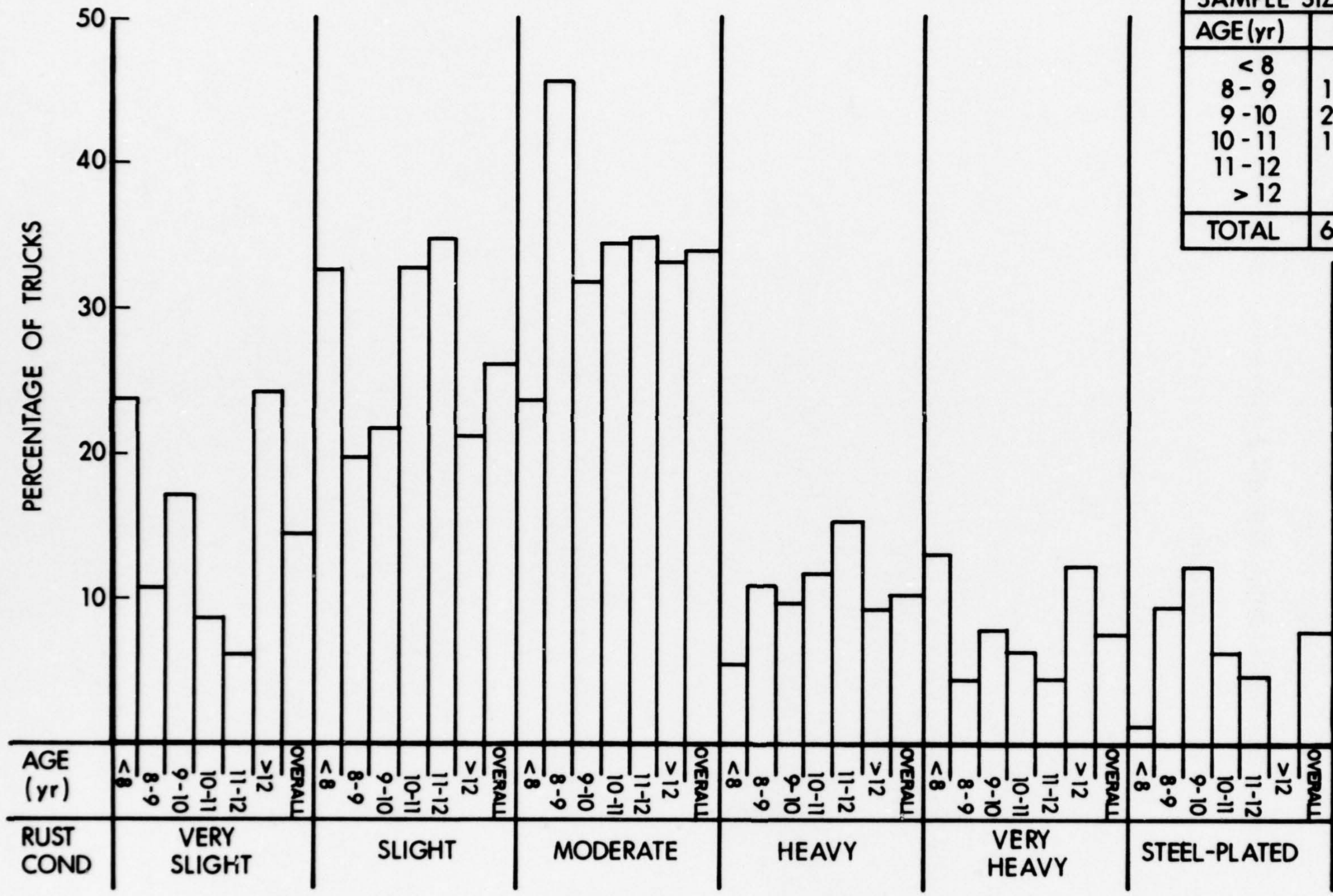
In the evaluation of the study results, an analysis of the relationship of rust condition to usage status was carried out. The object of this analysis was to determine if the severity of rust was dependent on usage status. It should be noted that the vehicles in the four usage categories were about the same age and mileage (see Table II) with the exception of the mileage on the pre-positioned stock vehicles which averaged near 6500 miles as compared to all vehicles which averaged near 22,000 miles. Thus, the effect that differing ages and mileages might have on a usage status analysis is minimal.

In the analysis of the rust condition of the six vehicle body areas as a function of usage status, a chi-square (X^2) test (similar to that carried out for the age affect analysis) was conducted to determine if rust condition was independent of usage status for each of the six areas. As an example of the various analyses carried out, the analysis of the frame/cross members area is presented. The data utilized in the analysis are summarized as follows:



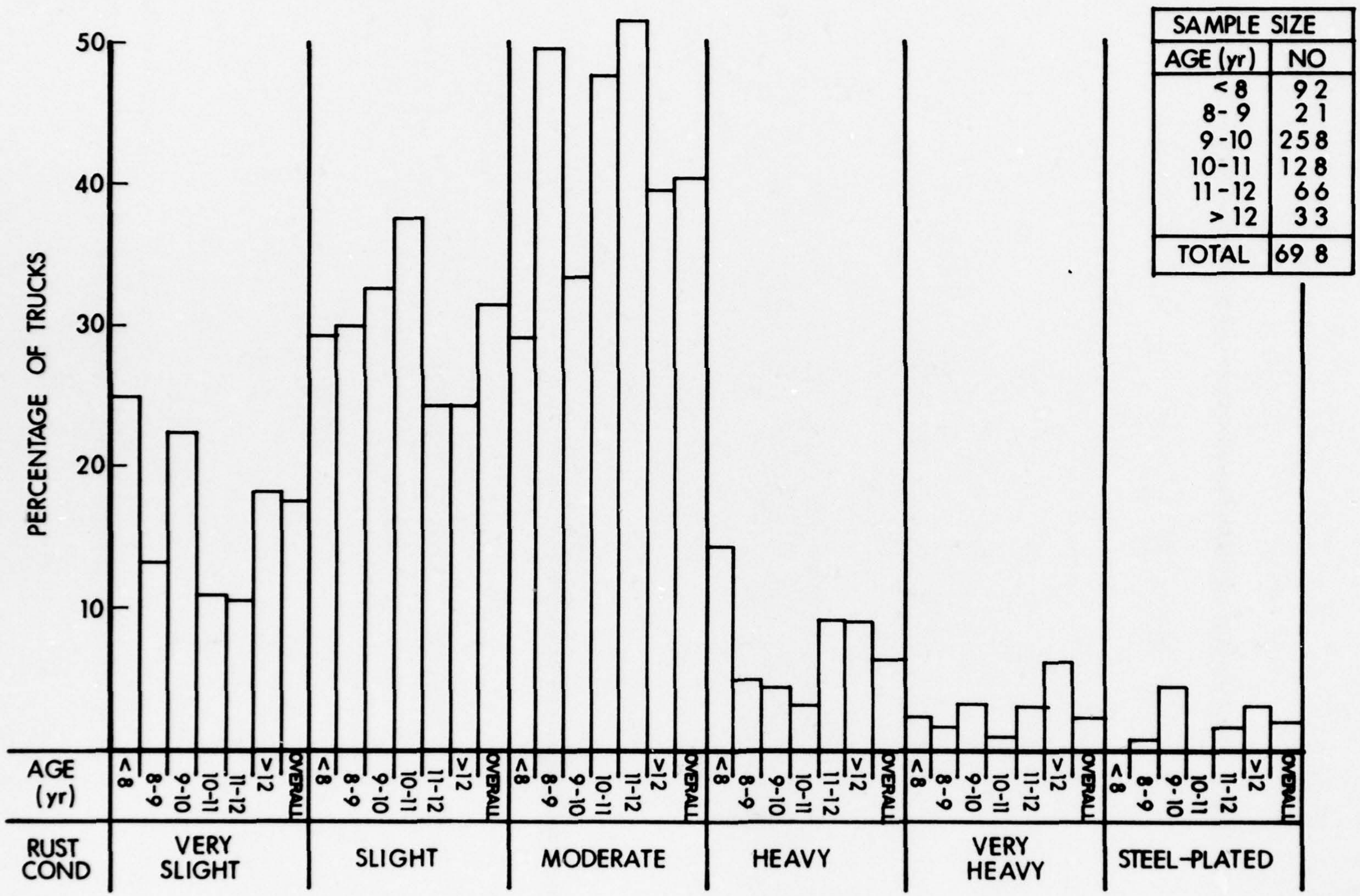
SAMPLE SIZE	
AGE (yr)	NO
< 8	93
8 - 9	121
9 - 10	257
10 - 11	128
11 - 12	66
> 12	32
TOTAL	697

Figure 5.1 (U) Rust Condition of Frame/Cross Members for 1/4 Ton Truck. (by age)



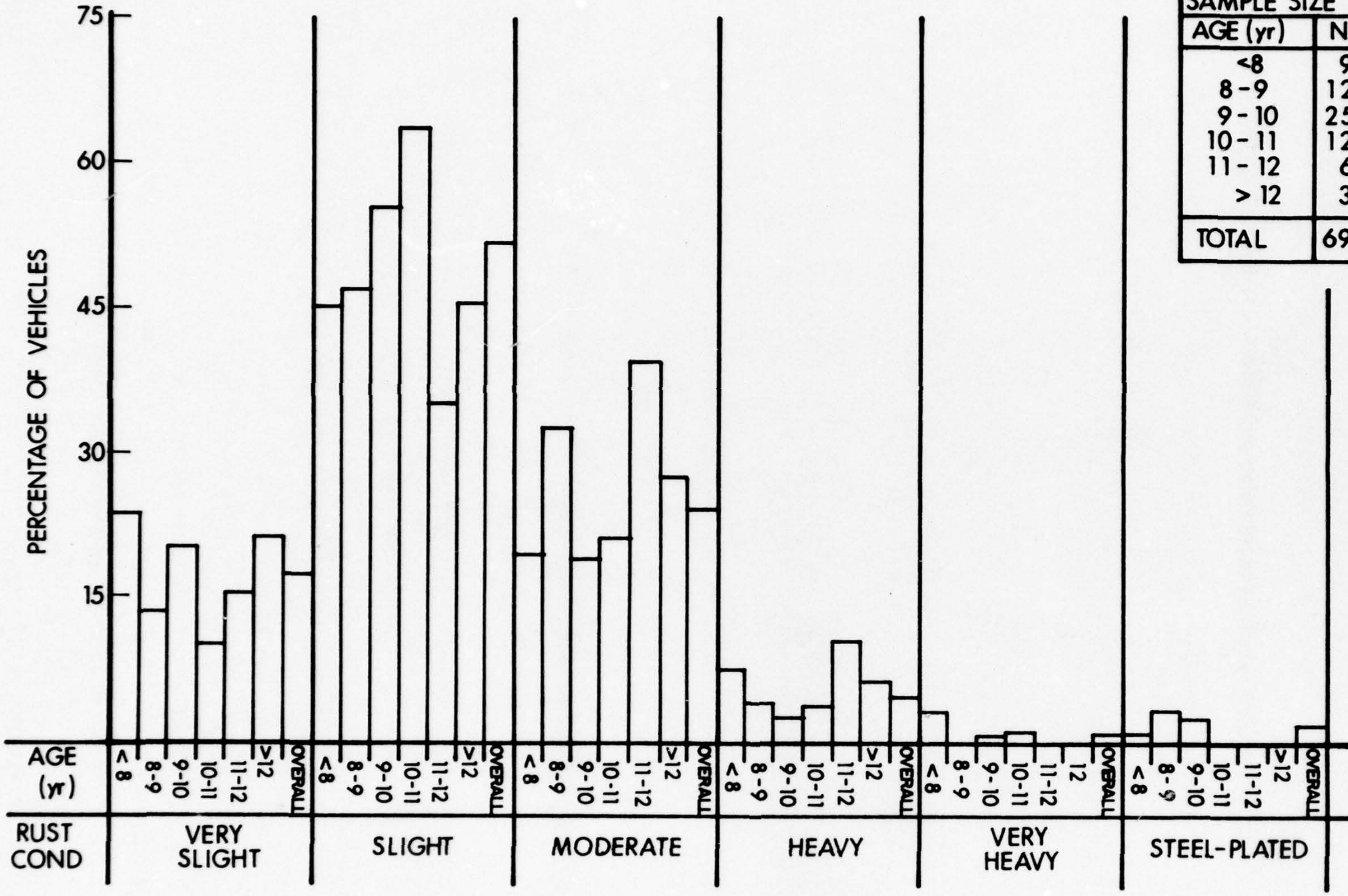
SAMPLE SIZE	
AGE (yr)	NO
< 8	92
8 - 9	121
9 - 10	258
10 - 11	128
11 - 12	66
> 12	33
TOTAL	698

Figure 5.2(U) Rust Condition of Front Floor for 1/4-Ton Truck.
(by age)



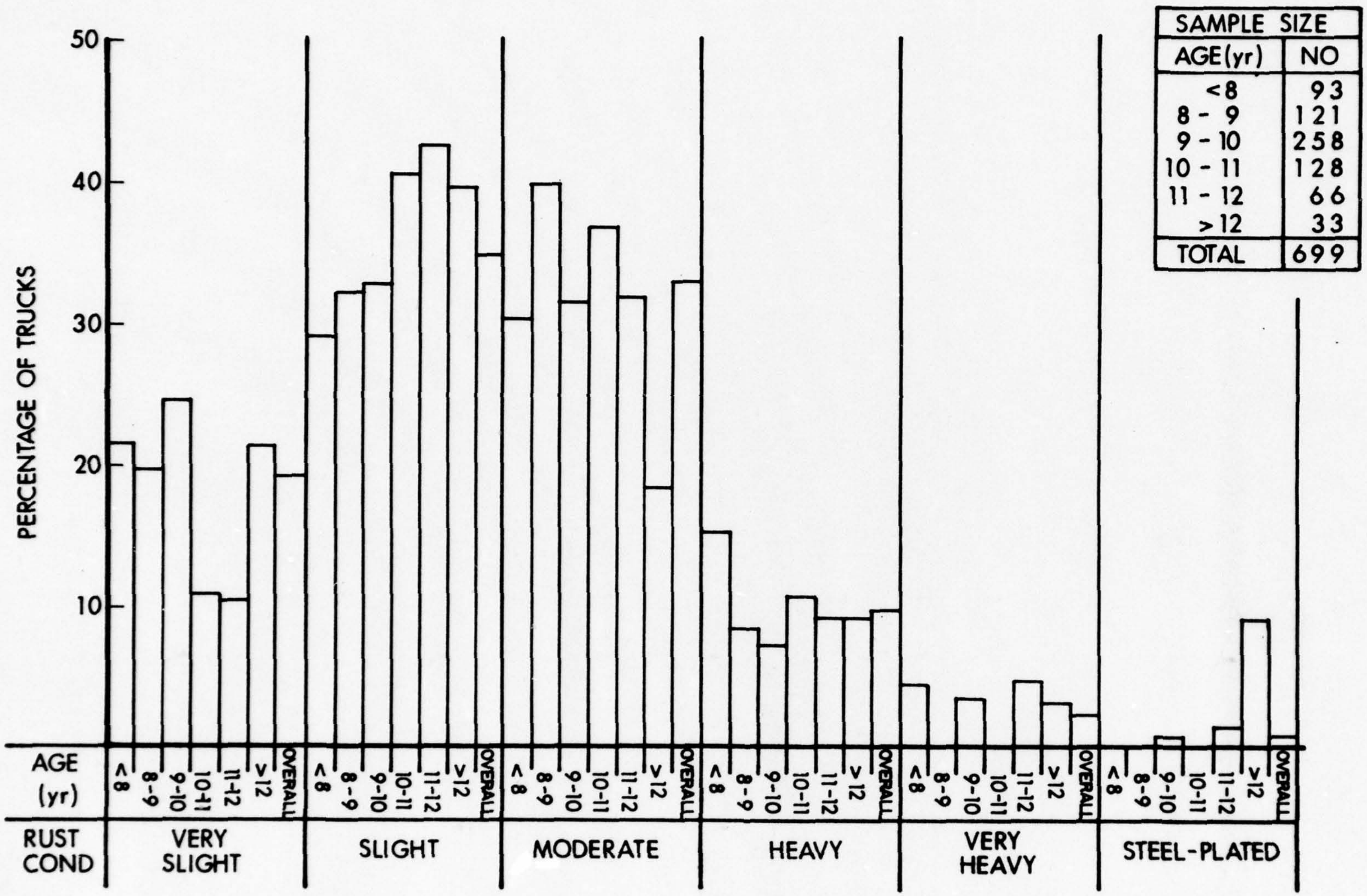
SAMPLE SIZE	
AGE (yr)	NO
< 8	92
8 - 9	21
9 - 10	258
10 - 11	128
11 - 12	66
> 12	33
TOTAL	69 8

Figure 5.3(U) Rust Condition of Rear Floor for 1/4-Ton Truck.
(by age)



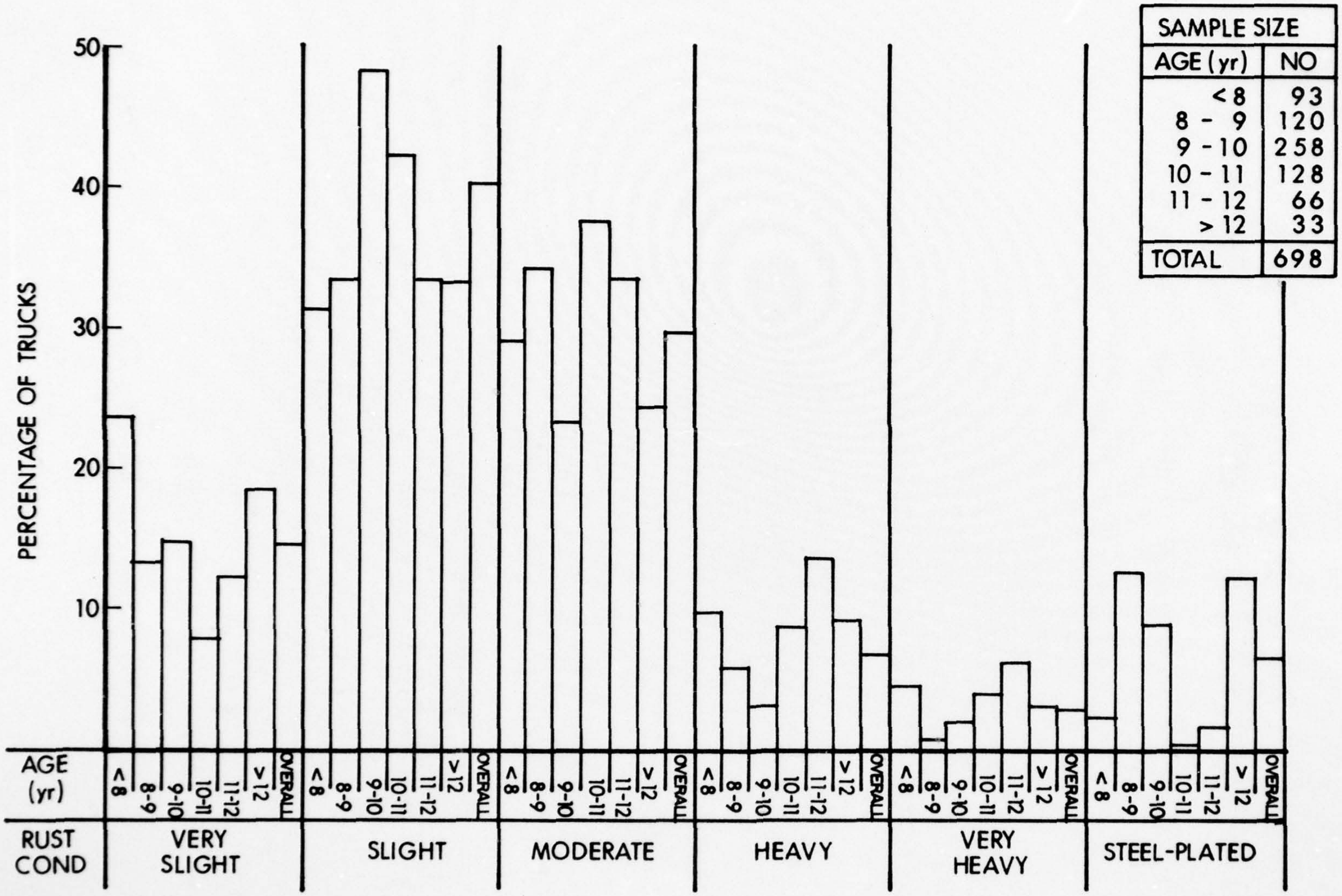
SAMPLE SIZE	
AGE (yr)	NO.
<8	93
8 - 9	120
9 - 10	258
10 - 11	128
11 - 12	66
> 12	33
TOTAL	698

Figure 5.4 (U) Rust Condition of Front Fenders for 1/4 Ton Truck.
(by age)



SAMPLE SIZE	
AGE(yr)	NO
<8	93
8 - 9	121
9 - 10	258
10 - 11	128
11 - 12	66
>12	33
TOTAL	699

Figure 5.5(U) Rust Condition of Rear Fenders for 1/4 Ton Truck. (by age)



SAMPLE SIZE	
AGE (yr)	NO
< 8	93
8 - 9	120
9 - 10	258
10 - 11	128
11 - 12	66
> 12	33
TOTAL	698

Figure 5.6(U) Rust Condition of Hood/Body for 1/4 Ton Truck.
(by age)

Rust Condition*	Usage Status								
	Operational		Pre-Positioned Stock		Property Disposal		Salvage		Total
	f_i	F_i	f_i	F_i	f_i	F_i	f_i	F_i	f_i
Moderate or Less	217	238.5	108	80.7	160	169.0	54	50.8	539
Heavy or Worse	102	80.5	0	27.3	66	57.0	14	17.2	182
Total f_i	319	-	108	-	226	-	68	-	721

*In order to have adequate data for carrying out the X^2 test, the six rust conditions were grouped into moderate or less and heavy or worse categories.

As shown in this table, the f_i values are the observed frequencies and the F_i values are the theoretical or expected frequencies. Utilizing these frequencies in a X^2 test for independence, the following analysis is presented:

$$X^2 = \sum^{8} \frac{\left(f_i - F_i\right)^2}{F_i} = 46.91$$

with 3 degrees of freedom. For the .05 level of significance,

$$X^2_{.95}(3) = 7.81$$

Since the computed X^2 value (46.91) is greater than the critical value at the .05 level of significance, the null hypothesis of independence of the rust condition and usage status was rejected indicating that the rust condition did not have the same proportion of vehicles in the four usage status categories. This is readily evident on Figure 5.7 which shows the rust condition of the trucks in the four usage status categories for the six truck body areas studied. For example, in the frame/cross member and front floor areas, the pre-positioned stock had less than 5% of the vehicles with heavy or worse rust while the three other usage categories (operational, property-disposal and salvage) had approximately 20 to 35% of the trucks with heavy or worse rust. It is interesting to note that the trucks in the operational and property disposal category had about 30% of the trucks with heavy or worse rust (in the frame/cross member and front floor area) while

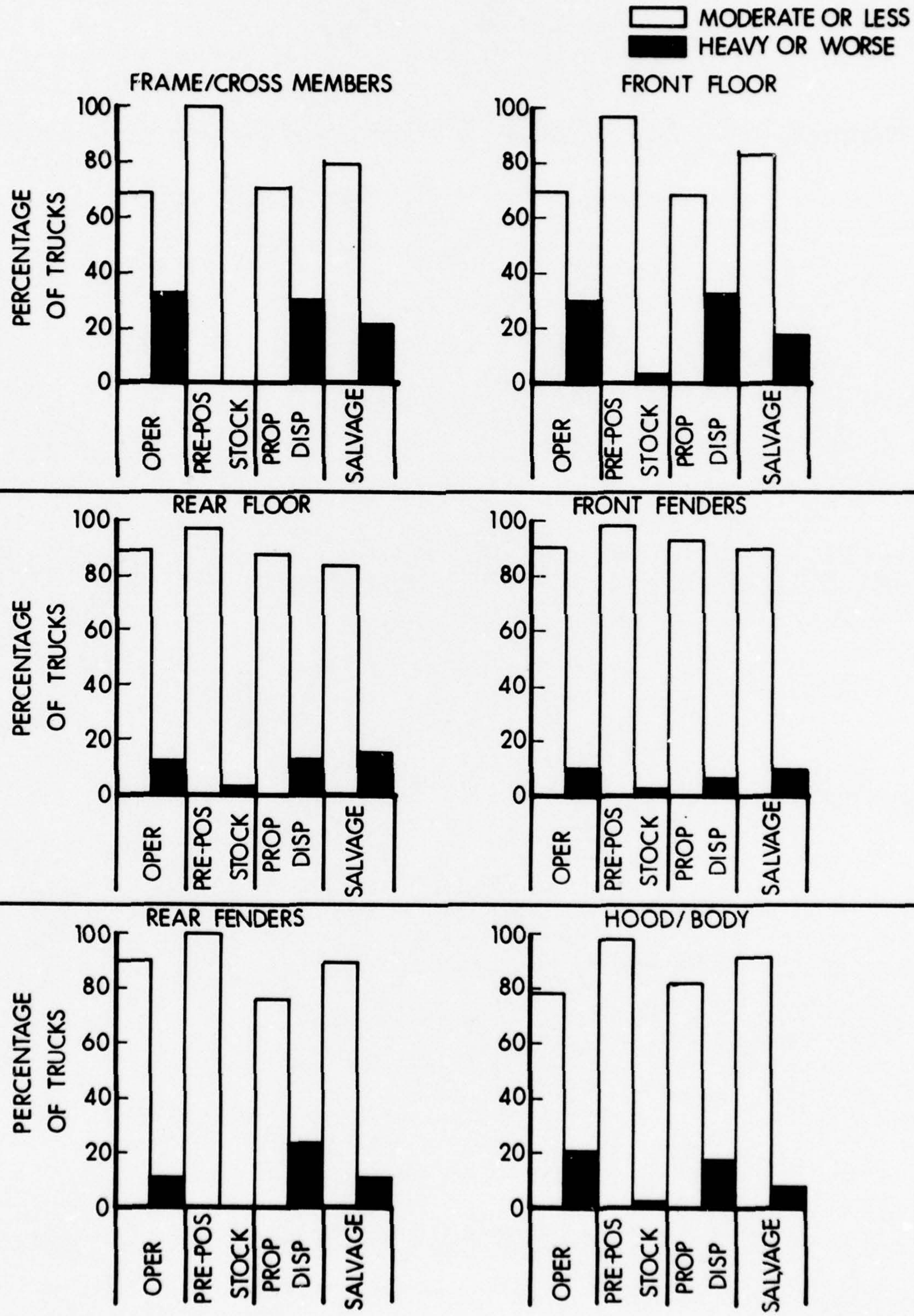


Figure 5.7(U) Rust Condition of 1/4 - Ton Trucks
(by usage status)

trucks in the salvage yard had about 20% of the trucks in the heavy or worse area. It is further noted that in the other four truck body areas, the percent of trucks in the salvage yard with heavy or worse rust was about the same or somewhat less than the operational or property disposal trucks.

5.4 Rust Versus Vehicle Location.

In an attempt to determine if vehicle location was related to severity of rust, all vehicles were separated according to the site at which the vehicles were located at the time of the survey. This resulted in the seven vehicle locations previously discussed. However, in the analysis of the rust condition by location, European vehicles were divided into two groups: (1) pre-position stock vehicles and (2) operational or salvage vehicles. This division was necessitated by the fact that the pre-position stock European vehicles showed substantially less rust than the operational or salvage European vehicles, all of which had been undercoated and were under controlled temperature/humidity storage conditions. Thus, a total of eight vehicle locations were studied.

Before presenting the results of the analysis, it should be mentioned that although the vehicles were located at the sites at the time of the survey, this does not imply that the vehicles have been at these sites since procurement. In fact, Army vehicles are known to move as units are relocated. The National Guard units in particular generally receive active Army vehicles that have some age and mileage on them. As a result, in the investigation of location differences, the results can provide some indication of whether there are differences in the severity of rust between locations at the time of the survey but should not be interpreted to mean that if vehicles were utilized at the sites indicated since procurement that they would necessarily have the rust conditions found (see Figure 5.8).

As carried out with the above rust vs. age and usage status evaluations, an analysis of the relationship of rust condition to vehicle location was carried out. In separating the vehicles according to location, the vehicles in the location groups were determined to be of about the same age and mileage (except for the lower mileage on the Europe pre-positioned stock vehicles), thus, reducing the effect that differing ages and mileages would have on the study to a minimum (see Table 3.2).

In the analysis of the six vehicle body areas as a function of location, a chi-square (X^2) test (similar to that carried out for both the age and usage status analyses) was conducted to determine if rust condition was independent of location for each of the six areas. As an example of the various analyses carried out, the analysis of the frame/cross member area is presented. The data utilized in the analysis are summarized as follows:

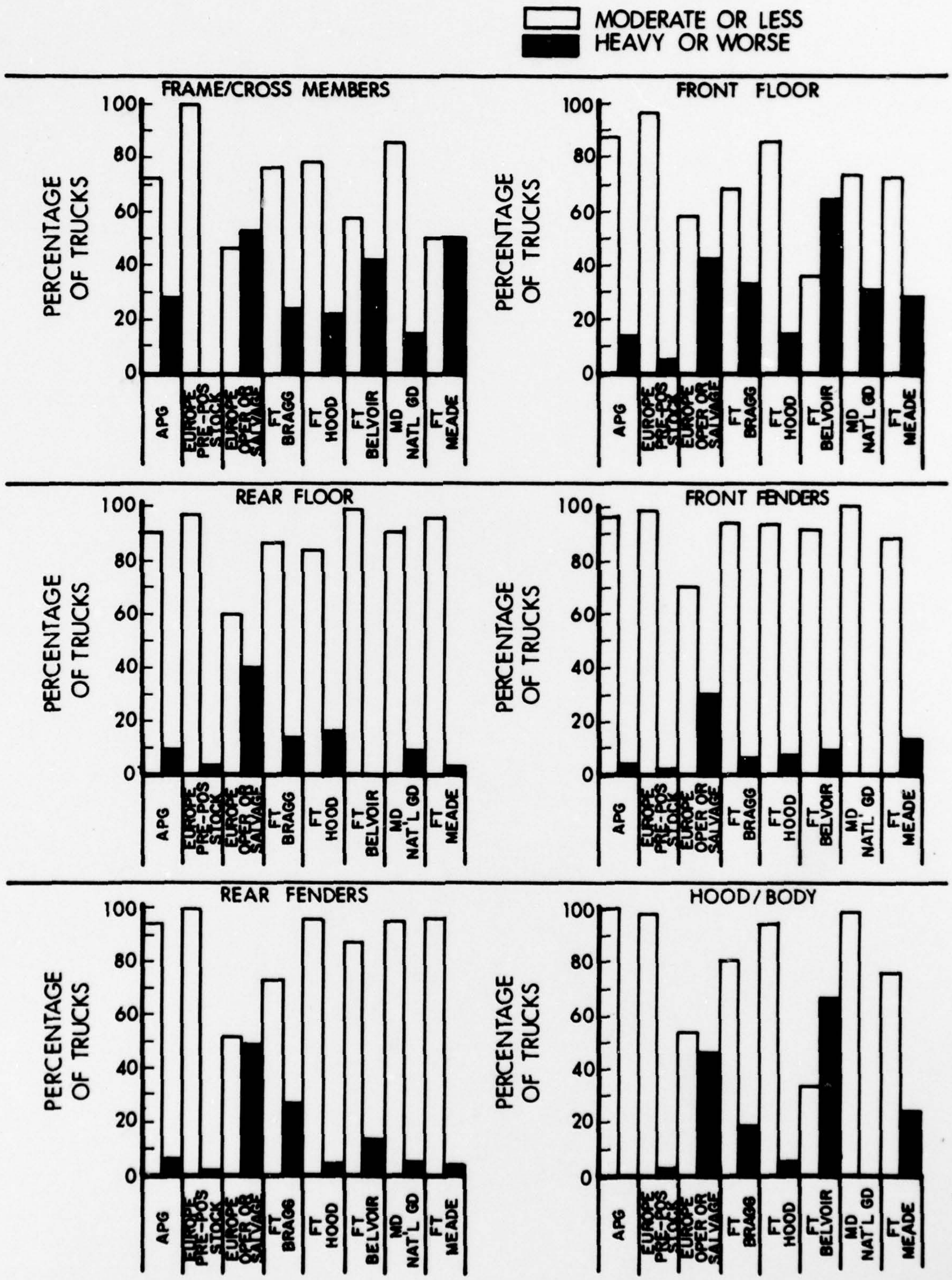


Figure 5.8(U) Rust Condition of 1/4 Ton Truck (by location).

Location	Rust Condition*				Total
	Moderate or Less		Heavy or Worse		
	f_i	F_i	f_i	F_i	f_i
APG	16	16.5	6	5.5	22
Europe Pre-Pos. Stock	108	80.8	0	27.2	108
Europe Oper. or Salvage	22	35.2	25	11.8	47
Ft. Bragg	155	151.1	47	50.9	202
Ft. Hood	75	53.2	20	41.8	95
Ft. Belvoir	14	18.0	10	6.0	24
Maryland Nat'l Guard	90	78.6	15	26.4	105
Ft. Meade	58	86.8	58	29.2	116
Total f_i	538	-	181	-	719

*In order to have adequate data for carrying out the X^2 test, the six rust conditions were grouped into moderate or less and heavy or worse categories.

As noted in this table, the f_i values are the observed frequencies and the F_i values are the theoretical or expected frequencies. Utilizing these frequencies in a X^2 test for independence, the following analysis is presented:

$$X^2 = \sum^{16} \frac{\left(f_i - F_i\right)}{F_i} = 124.93$$

with 7 degrees of freedom. For the .05 level of significance,

$$X^2_{.95}(7) = 14.07$$

As with the age and usage status analysis, the computed X^2 value (124.93) is greater than the critical value at the .05 level of significance, the null hypothesis of independence of the rust condition and location was rejected indicating that the rust condition did not have the same proportion of vehicles in the eight location categories. In examining this difference (see Figure 5.8) it is noted that in all six body areas examined, the European operational vehicles showed a relatively high percentage of vehicles with heavy or worse rust while the Ft. Hood vehicles showed a generally lower percentage of vehicles with heavy or worse rust. For example, in the frame/cross member and front floor areas, the European operational vehicles had approximately 55% and 40%, respectively, of the vehicles with heavy or worse rust while in these same areas the Ft. Hood vehicles had approximately 30% and 15%, respectively, heavy or worse rust. It is pointed out that Ft. Hood being in a hot-dry type environment has, of course, a much drier climate than Europe.

Relatively high percentages of heavy or worse rust were also noted at Ft. Belvoir and Ft. Meade, areas subject to wet climates as well as road salt.

6. REPAIR OF RUSTED VEHICLES

During the conduct of the rust data collection effort, it was noted that some units were involved in repairing 1/4 ton trucks that had a very heavy rust condition. In particular, the Director of Industrial Operations (DIO) at Ft. Meade was engaged in procedures that repaired severely rusted sections of the truck at relatively modest cost. More than 30 trucks had been repaired at an average cost of $100 each, with the highest cost being approximately $250. In view of the apparent success that Ft. Meade has had in repairing these trucks, a brief discussion of the Ft. Meade procedures for repairing the frame/cross members and front floor areas is presented since these two areas, as previously noted, were considered the most important areas of the truck unit body.

6.1 Frame/Cross Members.

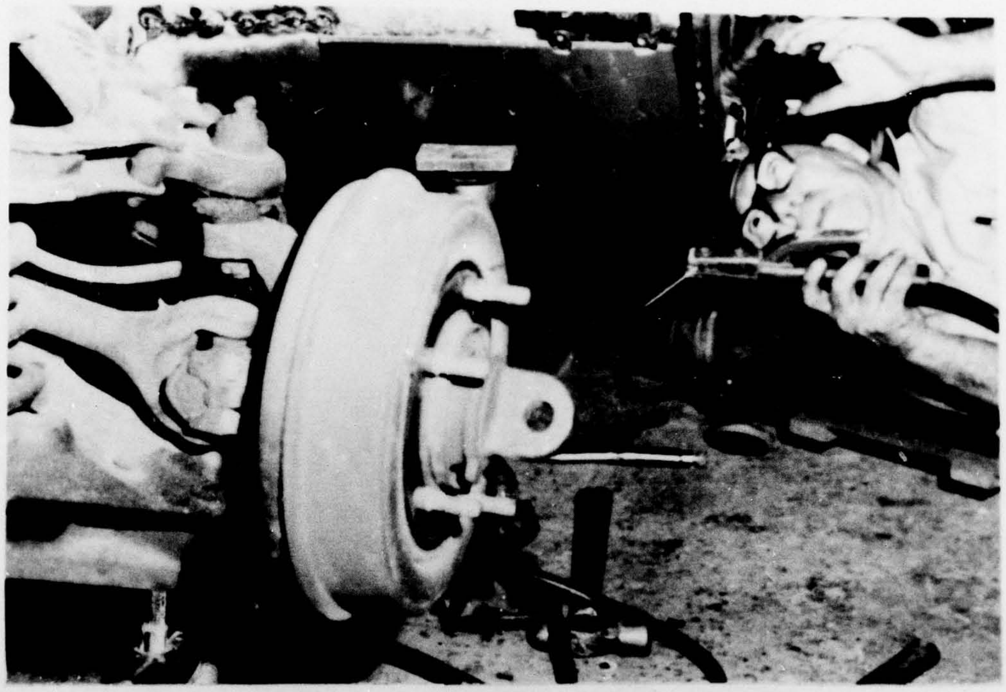
Utilizing some of the procedures outlined in TM-9-2320-218-34 for repairing structural damage, Ft. Meade applied them to repairing severely rusted frame/cross members. In general, the method involved covering the rusted area with pre-formed or pre-shaped steel plates and electric welding them in place. Photographs 6.1 and 6.2 show a rear cross member and the left front, respectively, prior to being repaired. Photograph 6.3 shows pre-formed steel plates being welded over the left underside of the cross member. The method of capping the cross member, which is outlined in the above referenced TM, is shown in photograph 6.4. Photograph 6.5 shows a typical example of of the left and right underside of a 1/4 ton truck after the front and rear cross members have been repaired, primed, and painted.

6.2 Front Floor.

Utilizing the same methods previously mentioned, Ft. Meade also applied them to repairing rusted front floor pans. Photographs 6.6 thru 6.9 show a typical severely rusted right front floor pan, right and left front floor pans after the new metal floor pan inserts were welded in place, and a left front floor pan after being repaired, primed, and painted, respectively. It should be noted that the new metal floor pan inserts far overlap the rusted areas to assure maximum strength of the repair (see photographs 6.7 and 6.8).

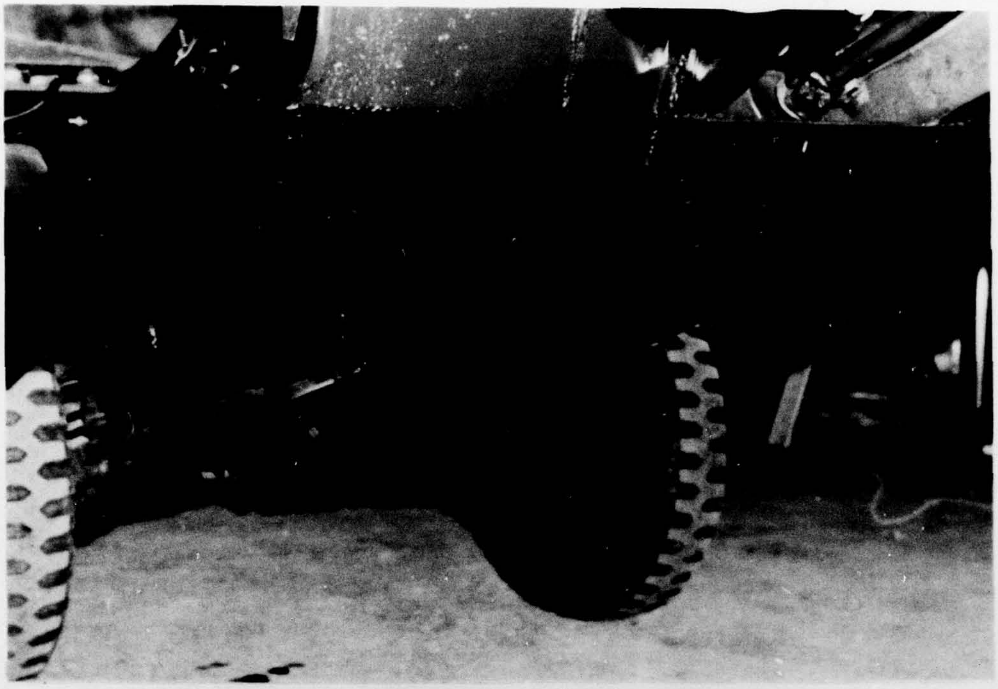
Photograph 6.1 - Typical Example of Severely Rusted Rear Cross Member.

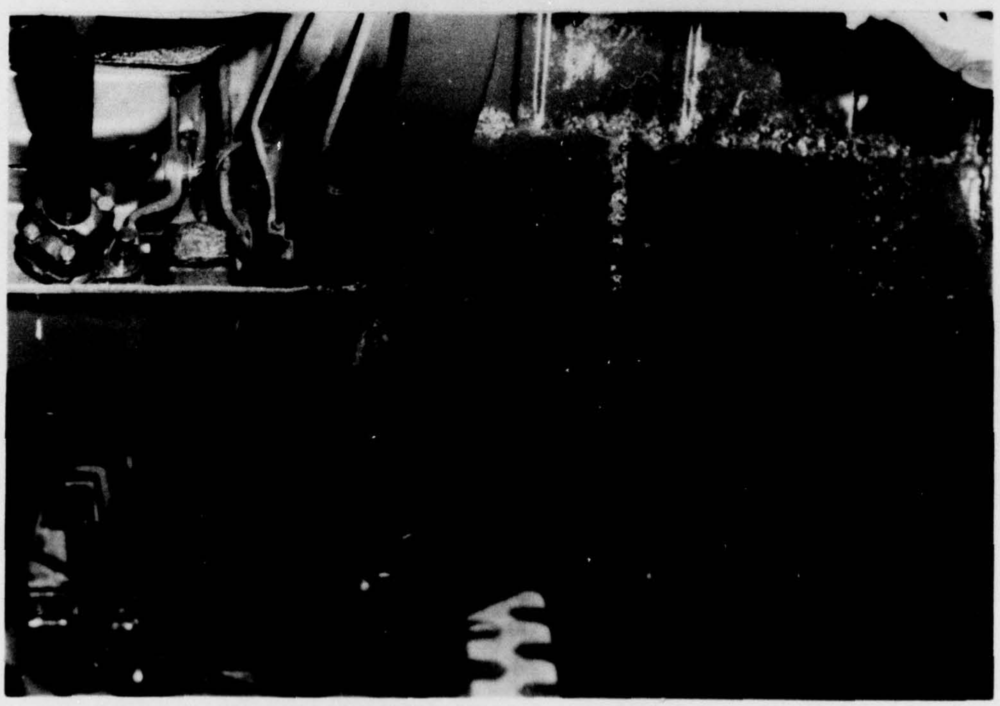
Photograph 6.2 - Typical Example of Severely Rusted Left-Front Cross Member.



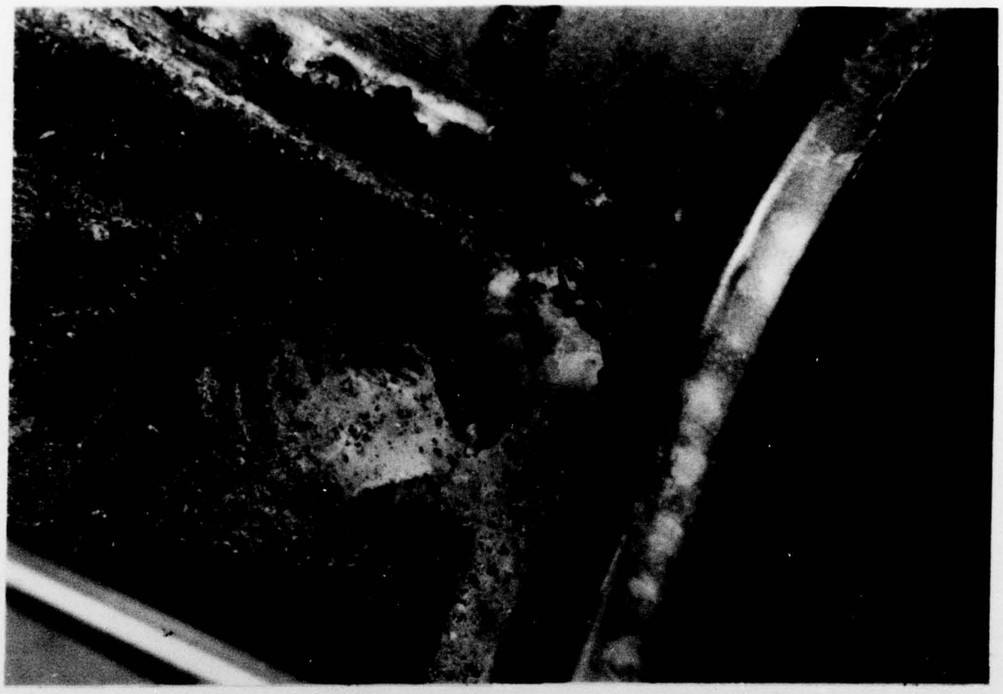
Photograph 6.3 - Preformed Steel Plates Being Welded to Left Underside of Front Cross Member.

Photograph 6.4 - Capping of Cross Member Under Transmission as Per TM-9-2320-218-34.

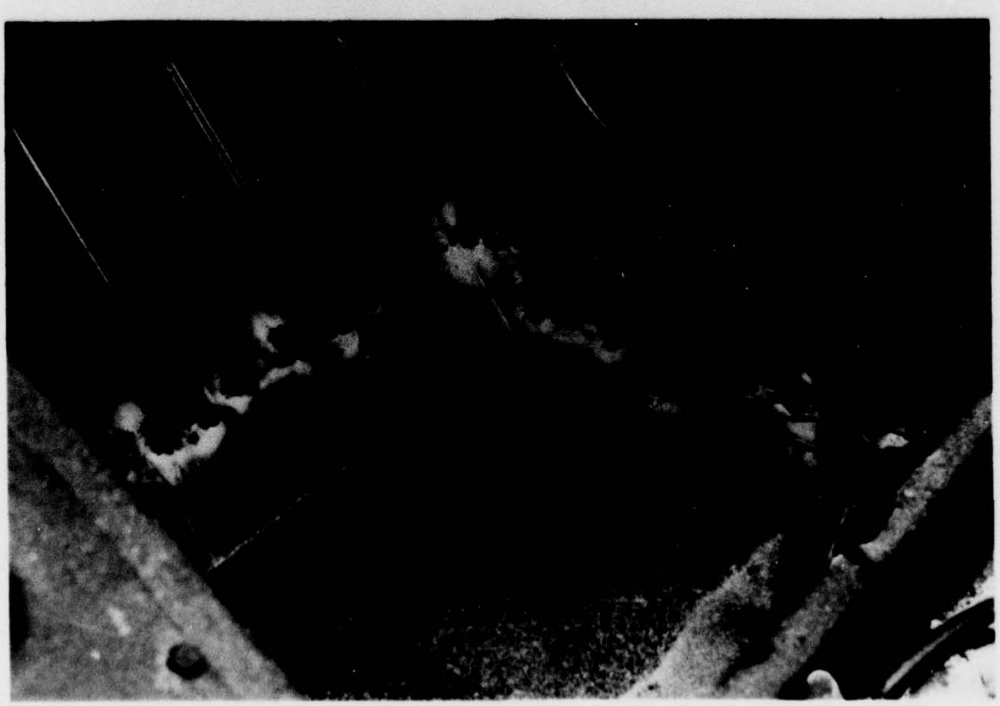




Photograph 6.5 - Left and Right Underside Showing Front and Rear Cross Members as Repaired.



Photograph 6.6 - Typical Example of Severely Rusted Front Floor Plan.



Photograph 6.7 - Right-Front Floor Pan with Metal Insert Welded in Place.

Photograph 6.8 - Left-Front Floor Pan with Metal Insert Welded in Place.

Photograph 6.9 - Left-Front Floor Pan as Repaired.

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3. Fleiss, J. L., Statistical Methods for Rates and Proportions, Johy Wiley and Sons, Inc., New York, 1973.

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APPENDIX

TWO-WAY CLASSIFICATION, INDEPENDENCE

A sample of n vehicles is classified according to two characteristics A and B in which there are r classifications for A and s classifications for B. The frequency of vehicles in i^{th} classification of A and the j^{th} classification of B is f_{ij}. This two-way classification table is then an r x s contingency table with cell frequencies f_{ij} such that

$$\sum_{i=1}^{r} \sum_{j=1}^{s} f_{ij} = n.$$

The hypothesis to be tested is that the two characteristics A and B are independent, i.e., the distribution of one characteristic is the same regardless of the other characteristic.

Consider the following r x s contingency table:

Characteristic A	Characteristic B							Total
	B_1	B_2	B_3	....	B_j	....	B_s	
A_1	f_{11}	f_{12}	f_{13}	....	f_{1j}	....	f_{1s}	$f_{1.}$
A_2	f_{21}	f_{22}	f_{23}	....	f_{2j}	....	f_{2s}	$f_{2.}$
A_3	f_{31}	f_{32}	f_{33}	....	f_{3j}	....	f_{3s}	$f_{3.}$
⋮	⋮	⋮	⋮	::::	⋮	::::	⋮	⋮
A_i	f_{i1}	f_{i2}	f_{i3}	....	f_{ij}	....	f_{is}	$f_{i.}$
⋮	⋮	⋮	⋮	::::	⋮	::::	⋮	⋮
A_r	f_{r1}	f_{r2}	f_{r3}	....	f_{rj}	....	f_{rs}	$f_{r.}$
Total	$f_{.1}$	$f_{.2}$	$f_{.3}$	....	$f_{.j}$	....	$f_{.s}$	n

If we let

P_i = the marginal probability that a vehicle falls in classification A_i

P_j = the marginal probability that a vehicle falls in classification B_j

P_{ij} = the probability that a vehicle falls in A_i and B_j

then the null hypothesis is

$$H_o: \; P_{ij} = P_i P_j, \; \sum_{i=1}^{r} P_i = 1, \; \sum_{j=1}^{s} P_j = 1$$

To test H_o, first compute the theoretical frequency, F_{ij}, of vehicles for each cell under H_o by using the 'marginal' frequency totals, $f_{i.}$ and $f_{.j}$, from the contingency table as follows:

$$F_{ij} = \frac{f_{i.} f_{.j}}{n} \quad i = 1,2,\ldots,r \quad j = 1,2,\ldots,s$$

Next, compute the statistic

$$\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{s} \frac{\left(f_{ij} - F_{ij}\right)^2}{F_{ij}},$$

which is distributed approximately as chi-square with (r-1)(s-1) degrees of freedom.

Then, for some level of significance α, accept H_o if $\chi^2 \leq \chi^2_{1-\alpha}$ (r-1)(s-1) where $\chi^2_{1-\alpha}(r-1)(s-1)$ is the $(1-\alpha)$ percentile of the χ^2 distribution with (r-1)(s-1) degrees of freedom. This χ^2 approximation is adequate if no more than 20 percent of the cells have theoretical frequencies less than five with a minimum of one.

If the totals $f_{i.}$ or $f_{.j}$ are specified in advance, the hypothesis tested is actually that the various A_i (or B_j) have the same proportions of vehicles in the various categories of B (or A).

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