BONDED STRUCTURE PERFORMANCE UNDER HOSTILE ENVIRONMENTS AND DYNAMIC TESTS

A.M. EASA
Assoc. Prof,. Production Engg. & Mech. Design Dept.,
Faculty of Engg., University of Menoufia, EGYPT

ABSTRACT

This work is concerned with the investigation of the effects of adherend materials, adhesive thickness, surface roughness and joint types on the impact strength for adhesive butt joints. Single and double butt strap joints were used. The bar materials were mild steel or aluminum, while the strap materials were mild steel and aluminum coated or uncoated with polyester laminates.

The long term durability of adhesive joints had been assessed as a function of the environment to which the joint was exposed. The tests were, tensile test and wedge test. In comparison, the torsion test was used to provide more data about the performance of the joints in hostile conditions. The specimens were made from mild steel. These specimens were left a certain time in oil of lubricant or coolant fluid. Other groups were treated and subjected simultaneously to an applied stress.

On the other hand, an impact vibration technique was used for the measurements of global bonding joint characteristics utillizing modal analysis.

The results show that the impact and static strengths depend on bar, strap materials and joint types. The dispersion of the strength of bonded joints is large specially when the lap length is short. Thus, it is necessary to pay attension in comparing the static strength with the impact one for bonded joints having short lap length.

The effect of strap materials and surface roughness (C.L.A.) on the strengths varies with the type of joint. The polyester laminates give good results in static strength as compared with the

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other materials of straps. The range of surface roughness which gives maximum joint strengths are 15 to 30 μm for (SB) joints and from 20 to 30 μm for (DB) joints. The strengths of joints increase with the increase in adhesive thickness until 150 μm. The simple short-term test allows prediction of the time to failure of the joint, provides an assessment of the effects of the environment and stress level on joint durability. The double torsion test can provide valuable informations concerning the strength and durability of adhesive joints. The double straps joint gives good results in all types of tests and in the different hostile environments.

From the modal analysis, there is a frequency dependance on the elastic modulus, damping, complex elastic modulus and wave velocity of the bonding which depends on the adhesive ratios and joint dimensions.

NOMENCLATURE

A : Vibration acceleration, arbitary units,
d : Joint diameter, m,
E : Elastic modulus, N/m^2,
E' : Elastic modulus, real part,
E'' : Elastic modulus, imaginary part,
E_a : Elastic Modulus of adhesive,
F : Exciting force, arbitrary units,
f_n : Resonant frequency, of n th mode, Hz,
A/F : Vibration accelerance, dB,
K : End condition depends on fixing method and mode number,
L : Joint length, m,
P_f : Final load, N.
n : Mode number,
t : Adhesive thickness, μm,
t_n : Sample thickness in the plane of the crack,m,
V : Wave velocity m/sec,
ρ : Mass density, Kg/cm^3,
ζ : Materal demping factor, (%),
w : Sample width, m,
Δf : -3dB, bandwidth,

1- INTRODUCTION

The adhesive bonded structure has advantages over mechanical fasting. However, the adhesive bonding is not used so frequently as a mechanical fasting because of less realibility [1]. Hence revealing characteristics of strength of adhesive bonding is very important. In addition, the studies about impact strength of adhesive, especially impact tension strength of the bonded joints are necessary which have been neglected in most of the previous work /2,3,4 and 5/. A continuing problem with this from of joining is that the joint strength can be significantly reduced with time when the joint is subjected to certain hostile environments. In particular; water ingress into the adhesive often results in rapid debonding /1/. This fact severely restricts the use of structural adhesives in many applications such as coolant and lubricant systems in machine tools. The problem with these remedies is that the particular surface treatment must be tailored for the adhesive-substrate surface /2, 3, 4, 6 & 7/. The considerable testing is required to optimize the durability of the adhesive joint.

The behaviour of adhesively-bonded joints depends on various factors, such as a cohesive strength of the adhesive and/or the interfacial bonding strength between the adhesives and the adherends /8/. The physical forces at the interface depend mainly on the surface structure, its morphology, the composition of the adherends and their affinity to the adhesive /9/. Generally, a failure of an adhesively-bonded joint is defined as a cohesive of the adhesive layer /9/. Failure of adhesive bonded joint could be also attributed to inadequate understanding of the adhesion failure mechanics /10/. There are many investigations which concerned with the failure modes /11/ and/12/. Most of them considered the behaviour under static conditions.

In the present work a study of static and impact strengths of butt joints was made. Test specimens were single and double butt strap joints of mild steel (MS) or aluminum bars.The straps were made from three different materials laminates. The problem of predicting long term durability of bonded joints is investigated by using short-term strength tests. Different shapes of mild steel joints were used. Various mechanical tests were used in terms of their ability to assess the durability of adhesive joints in hostile environments. Traditional tests such as tensile and wedge tests were used to be compared with a relatively complicated ones of the double torsion test.

Also, a modified technique is utilized for investigating the dynamic behaviour of bonded joint under impact vibration force. Type of fixation and adhesive thicknesses will be considered in the present work.

2- EXPERIMENTAL WORK

1.2- Types of Specimens

The specimens which used in this investigation are shown in Fig (1). The adherends were selected according to appropriate surface roughness (C.L.A) values for each adherend. The two parts of boned specimens were made from the same material (MS/MS and AL/AL) or combination of three materials. Preparation of surface to be bonded and mixing of adhesive was made according to the recommendations of the adhesive manufacture in each case /8 and 9/.

The mechanical properties and chemical composition of the two bars are given in Appendix A and B. The mechanical properties of adherend polyester laminates are given in Appendix C. The length of straps were 20, 30 and 40mm.

2.2- Surface Roughness Measurement And Bonding

The surface to be bonded for each specimen was cleaned and and foreign matter was removed , the measurement of the surface roughness was performed by using Talysurf 5-M 60 instrument.

The type of adhesive used in this investigation was supper-bonder 415. It has high impact strength, excellent solvent resistance, cures completely and leaves no residue on surface. The specifications of this type of adhesive are presented in Appendix D. After preparing the mixture of adhesive and selecting the adherends, the bonded joints were manufactured by applying the bonding agent to the cleaned surfaces. Then the joint was assembled in simple jig, which pressed the sections together. After the joint was fully assembled, the adhesive thickness was measured by using dial gauge. The bonded joint was removed from the simple jig after about three hours (setting time), then it was left 18 hours (curing time) in order to be fully cured before the treatment.The adhesive thickness was 200 µm. After curing time a group of different joints was treated in oil of lubricant and the others in coolant fluid for a certain time; 240, 480 and 720 hours Fig. (1-b). Other groups were treated and subjected simultaneously to an applied stress.

The oil of lubricant was (Delvac 1340 CD-Mobil G.M.C. 40). The coolant fluid was a distilled water with 5% Na OH solution.

In the case of impact vibration techniques, the two parts of bonded specimens were made from the same metal or a combination of the two metals Fig. (1-c).

3-2- Testing

The tensile machine was used in the static tensile tests, on the other hand, impact tensile tests were performed with an drop-weight type testing machine. All bonded joints were tested at room temperature to indicate the influence of surface roughness, type of adherend materials and adhesive thickness on the characteristics of these joints. The experimental tests were repeated five times for each joint shapes at different surface roughness (C.L.A).

In the case of hostile environments, three different techniques were used in these investigations as shown in Fig. (2). The simplest method for assessing the durability of adhesive joints in hostile environments is to conduct simple tensile tests before and after treatment. The breaking stress was recorded in the two previous cases. The second method of testing was wedge test. This method is very rapid and very simple to perform. The joint was treated in the hostile environment and the rate of crack growth is determined. The comparison test in these investigation was the double torsion test. This technique aims to combine the advantages of the wedge test with a more quantitive analysis based on the principles of fracture mechanics. The results were recorded before and after treating the different shapes of joints.

The impact vibration testing, technique is shown in Fig. (3-a) and described as follows; It is based on impact excitation testing technique, which is chosen, since it gives quick results, the impluse contains energy at all frequencies and will excite all modes simultaneously.The vibration signal is picked up using very light piezo electric accelerometer. The input and output signals (force & vibration) are connected with dual channel signal analyzer which was equipped with personal computer as shown in Fig. (3-a). On the basis of the experimental results of the eigenfrequencies, Fig (3-b), the flexability of damping criteria of both continuous and bonded joints are computed and plotted.

3- RESULTS AND DISCUSSION

1.3- Comparison Between Static and Impact Strengths

1.1.3- Strength of adhesive joint specimens

The results indicate that the variations of both impact and static shear strengths is significant. It seems that the reason of this result is the dispersion of the mechanical properties of the adherend and the quality of adhesive bonding. For decreasing this variation, impact and static test specimens were cut from one wide adhesive joint. Accordingly, the influence of the dispersion of the test specimens is small when comparing impact and static strengths of the same lot. Figs. (4a-f) show the mean value of impact and static shear strengths of each single butt (SB) joint. Figs. (5a-f) show the results of double butt (DB) joint. From these figures it is clear that, (in the case of L=20 mm) the dispersion of the mean value of strength of each lot is large having higher static strength than impact one for (SB) joints. In the same lot, the variation is not clear in comparison between strengths of different lots. It cannot be always described that, the lot having the higher static strength has the higher impact one. The double butt specimens show the same trend of the relation between impact and static strengths, the lot having higher impact strength has the less static one. This may be due to the increase of material and adhesive thicknesses.

2.3- Effect of Straps Types :

Types of straps used in this investigation are shown in Table (1)

JOINT NO. TYPE OF MATERIAL	1	2	3	4	5	6
BAR	MS	MS	AL	AL	MS	AL
STRAP	MS	AL	AL	MS	POL	POL

TABLE (1)

1.2.3- In the case of single strap joint :

Static and impact shear strengths of (SB-AL/AL), (SB-MS/MS), (SB-AL/POL) and (SB-AL/POL) joints are shown in Figs. (6a-b). Static strength of SB (MS) specimen with straps of (POL) laminates is higher than static strength of other types of joints. Impact strength of SB same trend of (MS/MS) joint is higher than that of SB (AL) and SB (POL). All joints give the decreasing shear strength as (L) increases. In the case of L=20 mm, SB (MS) joint has higher strength than the other joints. The strength of SB (POL) is near that of SB (MS) joint as (L) becomes larger up to 30 mm and 40 mm. Consequently the (POL) laminates have considerable effects on the strength of joint.

2.2.3- In the case of (DB) joints

Static and impact shear strengths of (DB-AL/AL), (DB-MS/MS), (DB-MS/POL) and (DB-AL/POL) joints are shown in Figs. (5a-c). Static strength of (DB-MS/POL) is slightly higher than that for the other joints for all values of (L). However, there is no much difference in the resultant strengths. Figs. (6a-b) show that, the change of adherend material plays an important role on the strengths of joints. When used (DB-AL/AL), the strength of joint decreased for all values of (L) as compared with (DB-MS/POL). The strength of the joint decreased for all values of (L) in the case of (DB-AL MS) compared with the (DB-MS/POL) joints. This is may be due to the mechanical properties of the type of adherend.

3.3- Effect of surface roughness

The surface roughness (C.L.A) values of the two parts of (SB) or (DB) is the same. Five values of (C.L.A) for three joints of (SB) and (DB) were used in these investigations. From Fig. (7) it is clear that the static and impact shear strengths of (SB-MS/MS) increase with the increase of surface roughness (C.L.A) in the range of machining proceses until it reaches to 25μm. Thus, the resultant value of static and impact shear strengths starts to decrease continuously with the increase of (C.L.A) value. The ranges of surface roughness which gives maximum joint strengths are 15 to 30 μm. Fig. (8) presents the behaviour of (DB-MS/MS) joint under different surface roughness (C.L.A) values. The results have the same trend as the previous results of (SB-MS/MS) joints. However, the surface roughness which gives highest value of strength is from 20 to 30 μm. The values of strengths of this type of joint are larger than the (SB-MS/MS) one by about 5%.

4.3- Effect of adhesive thickness

Four adhesive thicknesses were used in present work, namely (100, 150, 200 and 250μm). From Fig (9) it is shown that the adhesive thickness plays a vital role in the characteristics of (SB) and (DB) joints. The coefficient of variation of (static and impact shear strengths) for the adhesive thicknesses is large which is clear in the result of (DB) joint. The reason of this deviation is due to the damping coefficient of the adhesive material. Increasing of the adhesive thicknes leads to an increase in the strengths of the joint in certain limit. The shear strength increases by about 8% as compared with the result of the first one.

5.3- Hostile environments

5.3.1- In the case of tensile tests.

The breaking stress was recorded before and after treatment. The time of treatment was recorded. The rate of decrease in strength with treating time was taken as indicative of bond durability in that environment. Fig. (10) shows that there is a small change in joint strength when the time of treatment equal 240 hours. At 480 and 720 hours the strength of joint decreases with the increasing in the time of hostile environments. This is may be due to the chemical interaction between the adhesive material and the hostile environments.

On the other hand, group of joints were loaded during the hostile environments. In this case, the deviation between the results of time to failure under different conditions is very large specially when using oil of lubricant as shown in Fig. (11). This effect can be at ributed to the fatigue during the treatment.

5.3.2- In the case of wedge tests

In the wedge test, it is clear that, the slower the crack growth the more durable is the joint. Wedge tests on joints give similar trends to the creep cases. The oil of lubricant was effective than coolant fluid and this was more obvious than dry air as shown in Fig. (12). The main difficulty with the wedge test is that it is not quantitative. The data provided are only semi-quantitative and are useful only for comparing the same adhesive on the same substrate with varying environments, or with varying surface pre-treatments. It is clear that there is no relationship between the durability as measured by the wedge test and the actual time to-failure of the adhesive joint in service.

5.3.3- In the case of double torsion test

This type of test aims to combine the advantages of the wedge test with more quantitative analysis principles of fracture mechanics. Fracture mechanics involves characterizing the fracture resistance of a material by measuring the rate of crack growth through the material as a function of loading conditions, or the stress intensity factor. The crack speed can be considered as a function of the sress intensity factor. Fig (13) shows the load versus time trace obtained during a load relaxation test for the joint. The test was conducted in air, oil of lubricant and coolant fluid. It is clear that, the time to-failure in air environment gives a long time comparing with the others. In the case of lubricant oil, there is a drop of life time of joint. This may be due to the chemical interaction between the oil of lubricant and adhesive material. From the same figure it is found that, the double torsion testing configuration is a linear compliance geometry, it means that the crack propagates in a stable manner along the length of the bond.

On the basis of these results, it is possible to estimate the life time of the joint in three hostile environments. Using this method, it is possible to determine the induction time for environmental attack. The time from the first immersion of the joint in hostile environment to the decrease in load resulting from accelerated crack growth can be obtained from the load versus time trace as shown in Fig. (14). Now it is clear that, the double torsion method is able to measure the induction time comparing with other types of tests. On the other hand, the time of failure in these types of test varies with the type of hostile environment. The air enviroment gives good results as compared with the others. The oil of lubricant has a large effect on the time to failure for the various shapes of joints. The joint durability in the previous case is very short as compared with the others. The double strap joints gives better results compared with the other types of joints. The butt joints give lower values of results in all the previous tests. This is may be due to the decrease of bonding area compared with the other types of joints.

6.3- Modal model method

The elastic Young's modulus, dampig, complex elastic modulus, dynamic stiffness and wave velocity are determined experimentally using modal model method, by performing modal test of the joints. The modulus of elasticity "E" in the absence of damping can be found from the resonant frequency, mechanical dimensions of the joint, density of material and boundary conditions /20/. Fig. (15) presents the frequency dependance on elastic modulus for fixed-free case with two values of adhesive thickness (200 and 300 μm). This figure indicates that, when the frequency increases the elastic modulus decreases in the range of 250 to 950 Hz. This may be due to the mutual effects of the mechanical properties of the adhesive material and mild steel in the intereface region. The frequencies decrease in the region adjacent to the bonded joints. The region is mainly affected by the adhesive thicknesses.The elastic modulus values are large comparing with the results of continuous joint. The increase of the adhesive thickness increases the elastic modulus of the joint. In the case of (300 μm) thickness, the deviation between E values comparing with continuous joint is very clear, it is about 10%. Fig. (16) presents the frequency dependance on elastic modulus for fixed case of the same metal under the same conditions. This figure indicates that, the values of elastic modulus are less than the values which shown in Fig. (15) and the high modes are very sensitive to adhesive thickness. The results of elastic modulus when using (t=300 μm) are large comparing with continuous joint for (t=200 μm). Now, the adhesive thickness and type of clamping play an effective role in the behaviour of the joint for the same dimensions.

Figs. (17 and 18) present the frequency dependance on elastic modulus under the same conditions of Figs. (15 and 16). In this case the diameter of the joint is changing from 30 mm to 40 mm. From these figures, the amplitudes are large than the previous case specially for Fix-Fix condition. This may be due to the increase of joint diameter and adhesive thicknesses. From the same figures the effect of adhesive thickness is very clear as shown in the previous figures.

Figs. (19 - 22) present the frequency dependance on the damping ratios under the same conditions of the previous figures. This is expected, since as the frequency increases the damping ratio decreases. From the same figures, when the adhesive thickness increases comparing with the continuous joint, using diameter of joint equal 40 mm, the damping ratio increases as compared with fixed-fixed case which are represented in Figs. (21 and 22). Increasing damping ratio depends on many factors such as, the adhesive thickness, type of fixation and joint diameter.

Due to the demands of high speed operation and the use of light structures in modern machinery, static measurements of stress/strain properties are not sufficient. The static determination of the elastic modulus does not take into account the frequency or internal friction (damping). It is clear from the results of the elastic modulus and damping that there is a frequency dependance of these parameters. In the case of adhesive joint the internal damping is to be considered and the modulus of elasticity becomes a complex value. The complex value is the vectorial sum of the elastic and damping moduli which calculated as follows /20/.

$E = E' + i\,E''$ and ; $E = 2\zeta E'$, while the damping factor is; $\zeta = \frac{L}{2} \cdot \frac{\Delta f}{f_n}$

From the modal test (frequency response), the complex elastic modulus can be determined. It is obvious that the results depend mainly on the constituent ratios of the adhesive and joint conditions.

Figs. (23 - 26) present the frequency dependance of accelerance (A/F) for the various boundary conditions. This relation (A/F) can be taken as a measure of the dynamic stiffness. The use of accelerance of vibration as a preferred parameter because it covers a wide range of frequency and gives flatest spectrum. Since the displacement, velocity and acceleration signals are directly related, thus, vibration accelerance (A/F) as a measure of inverse of the dynamic stiffness is used.

From Figs. (23 - 26), the dynamic stiffness which is proportional with (A/F) decreases with anincrease in frequency , adhesive thickness, diameter of specimen, and type of fixation.These results may be due to the greater deflections produced from the vibrating force comparing with the elastic conditions and due to the behaviour of adhesive material under dynamic force. From the previous figures, it is clear that, the Fix-Fix case gives higher results comparing with the Fix-Free case since the first one increases the stiffness of the joint. The increase of (A/F) with the increase of frequency is either due to the decrease of damping with frequency or as a result of the decrease of dynamic stiffness.

The equation of the compressional vibrations has the same form as so-called wave equation which governs various types of wave phenomenon in theoretical physics. Compressional vibrations are referred to as mechanical waves with a wave velocity $V = \sqrt{E'/\rho}$

This parameter is very important because the actual vibrations measured on a complicated structure may be widely different from point to point, and from space direction to another. The wave solution is most duration, while for practical engineering analysis, the vibration solution is most useful. Figs. (27 - 30) present the frequency dependance on wave velocity. The wave velocity is directly related to the elastic modulus and inversely related to the density roots. From these figures, the decreases of sound velocity with the increase of the frequency is clear. The drop in elastic modulus for a certain frequency makes the wave velocity increases with the decrease of adhesive thickness because the adhesive thickness transmits the vibration signals or waves more difficult than the metal.

4- CONCLUSIONS

The results lead to the following:

1) The dispersion of the strength of bonded joints is large specially when the lap length is short. Thus it is necessary to pay attension in comparing the static strength with the impact one for bonded joints having the short lap length.

2) Effects of strap materials on the strength are varied by the type of joint.

3) Effect of the surface roughness (C.L.A)on the strengths of joint is varied by the type of joint.

4) The range of surface roughness (C.L.A) which gives maximum joint strengths is 15 to 30 μm for (SB) joints and from 20 to 30 μm for (DB) joints.

5) The strengths of joints increase with the increase of adhesive thickness until 150 μm.

6) The joint which has fiber contents gives good reuslts as compared with other one specially when the joint is under tension. Obviously, the use of polyester fibers in bonding joint is more economical as compared with other straps laminates.

7) The simple short-term test allows the prediction of the time to failure of the adhesive joint. It represents an assessment of the effects of the environment and stress level on joint durability.

8) The double torsion test provides valuable informations for the strength and durability of adhesive joints.

9) The oil of Lubricant (Delvac 1340 CD-Mobil-G.M.C. 40) has a large effect on the durability of adhesive joint.

10) The double straps joint gives good results in all types of hostile environments and in all types of tests.

11) There is a frequency dependance on the damping, complex elastic modulus and wave velocity.

12) The dynamic behaviour of bonded joint depends on the adhesive ratios and joint dimensions.

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Appendix (A)

The mechanical propertiesof the bar materials are as follows :

Mechanical Properties	UTS M Pa	YS G Pa	E G Pa	B. H.	% Elongation
MS	260	130	207	106	45
AL	86.2	32.5	6.7	24	48

Appendix (B)

The chemical composition of the two bars materials are as follows :

Chemical Composition	Fe	Si	Cu	Al	Mn	Ni	Cr	Mo	S	P	C
MS	bal	0.117	0.35	0.004	0.85	0.1	0.12	0.004	–	–	--
AL	0.4	0.25	0.2	bal	0.05	--	–	--	0.046	0.036	0.267

Appendix (C)

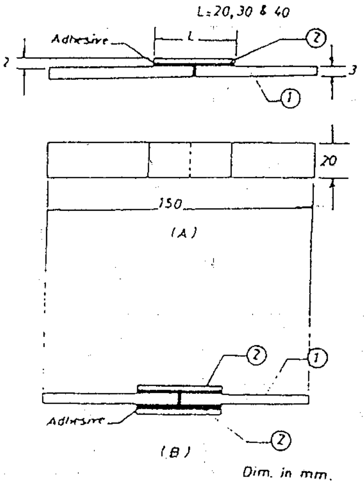
The mechanical peoperties of polyester materials are as follows :

Mechanical Properties	E G Pa	σ_u M Pa	Fiber contents Vol. %
Polyster	10.6	170	30.5

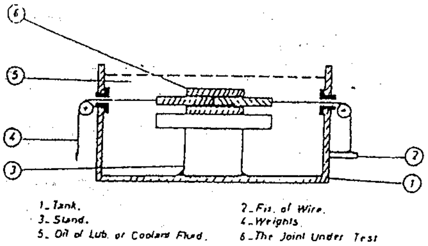
Appendix (D)

The specifications of "Super bonder 415" are as follows :

Specification at 20 °C	Chemical name	Colour	Viscosity	Typical Handling Strength	Typical Ultimate Strength	Gap Filling	Temp. Range	Min. Shelf Life
	Anearble	Amber	10 CPS	1 min	24 hrs $30\ N/mm^2$	0.25 mm	-55 : 120 °C	0 : 5 °C 1 Year

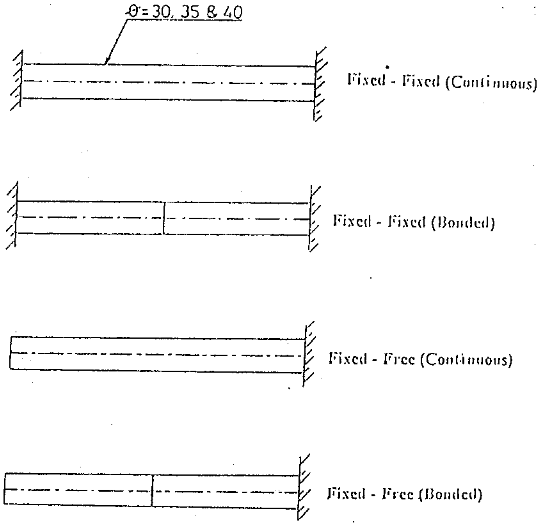


a) Dimensions of Test Specimens
A) Single Butt Starp Joint.
B) Double Butt Starp Joint.



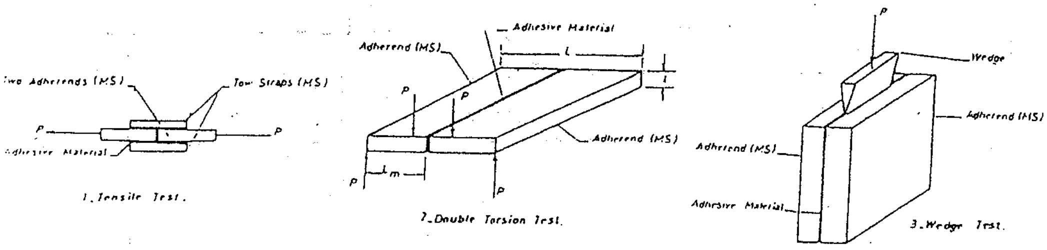
b) Test Rig For Different Joints's of Tensile Test.

Dim-in mm.



c) Fixation of butt joints for dynamic testing.

Fig. (1)

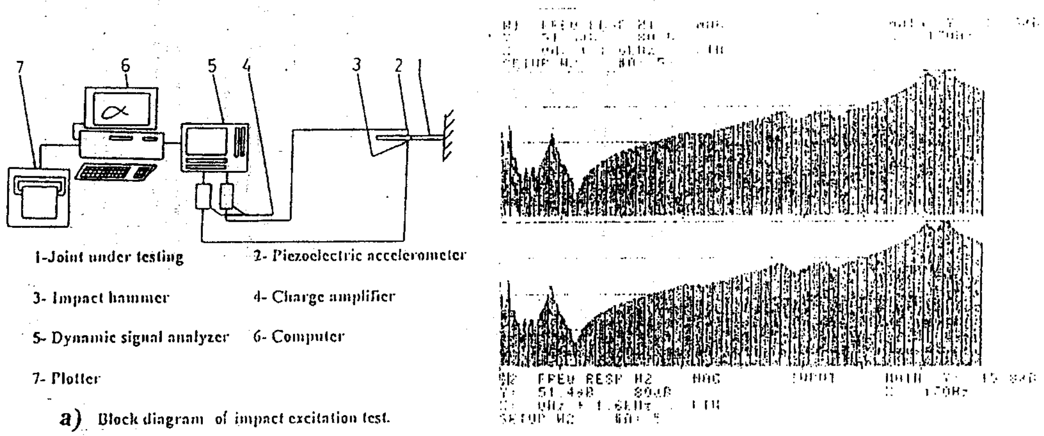


1. Tensile Test.

2_Double Torsion Test.

3_Wedge Test.

Fig.(2) Three Types of Tests Techniques.



a) Block diagram of impact excitation test.

Fig. (3)

b) Frequency response of a test sample.

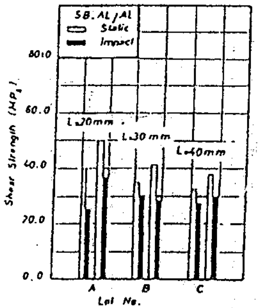


Fig.(4a) Static and Impact Shear Strengths of (SB) Joints in Each Lot.(AL/AL).

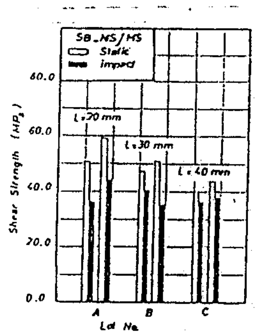


Fig.(4b) Static and Impact Shear Strengths of (SB) Joints in Each Lot.(MS/MS).

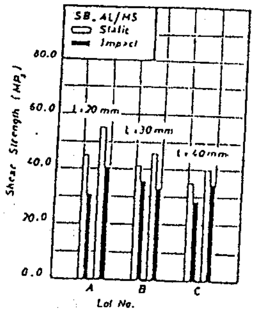


Fig.(4c) Static and Impact Shear Strengths of (SB) Joint in Each Lot.(AL/MS)

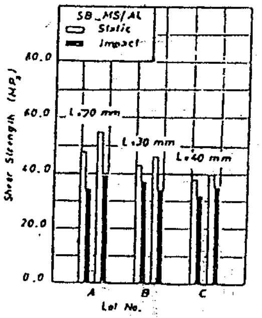


Fig.(4d) Static and Impact Shear Strengths of (SB) Joints in Each Lot.(MS/AL).

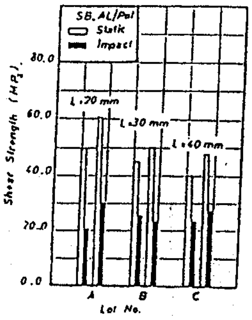


Fig.(4e) Static and Impact Shear Strengths of (SB) Joints in Each Lot.(AL/Pol).

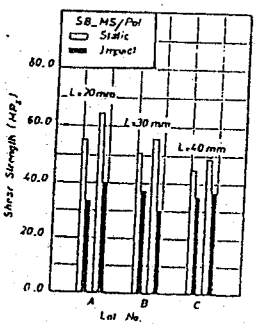


Fig.(4f) Static and Impact Shear Strengths of (SB) Joints in Each Lot.(MS/Pol).

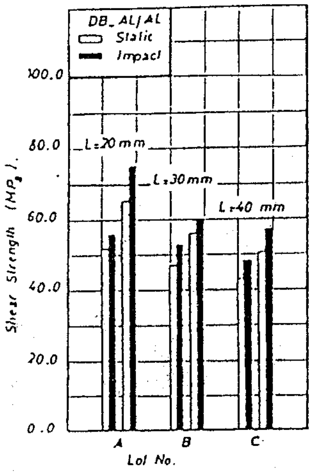


Fig.(5a) Static and Impact Shear Strengths of (DB) Joints in Each Lot.(AL/AL).

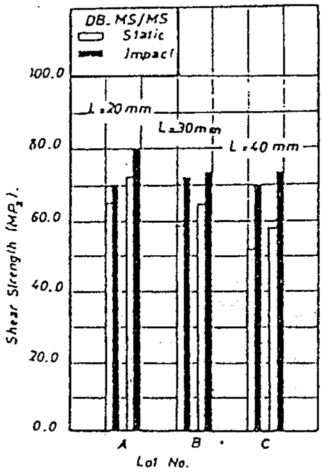


Fig.(5b) Static and Impact Shear Strengths of (DB) Joints in Each Lot.(MS/MS)

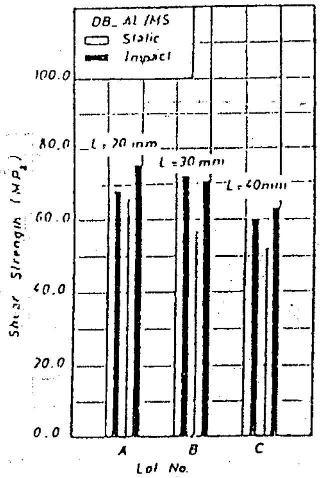


Fig.(5c) Static and Impact Shear Strengths of (DB) Joints in Each Lot.(AL/MS).

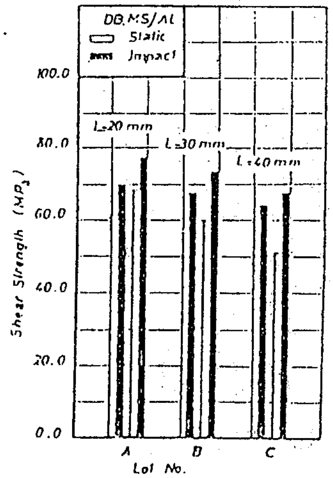


Fig.(5d) Static and Impact Shear Strengths of (DB) Joints in Each Lot.(MS/AL)

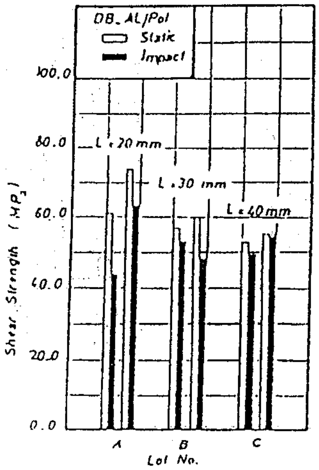


Fig.(5e) Static and Impact Shear Strengths of (DB) Joints in Each Lot.(AL/Pol).

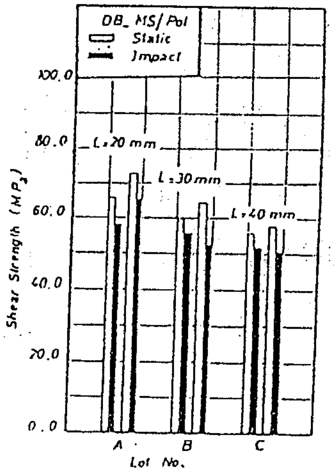


Fig.(5f) Static and Impact Shear Strengths of (DB) Joints in Each Lot.(MS/Pol).

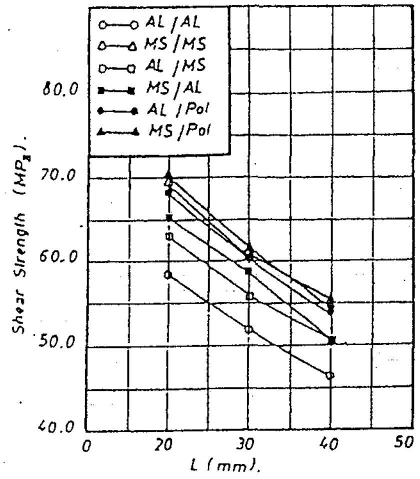


Fig.(6-a) Static Shear Strength of (DB) Joints.

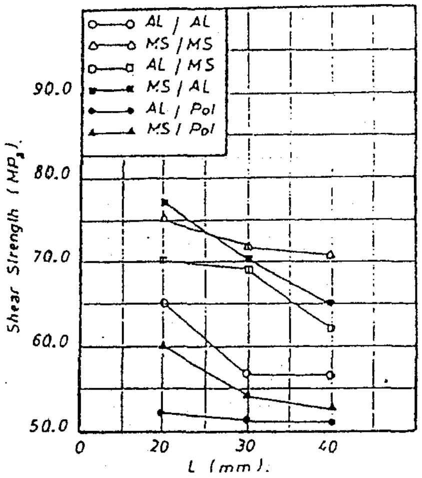


Fig.(6.b) Impact Shear Strength of (DB) Joint.

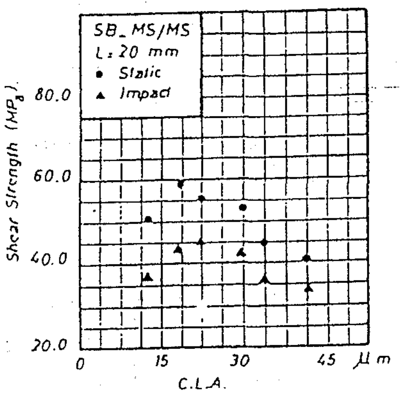


Fig.(7) Static and Impact Shear Strengths of (SB) Joints For Different Surface Roughness.

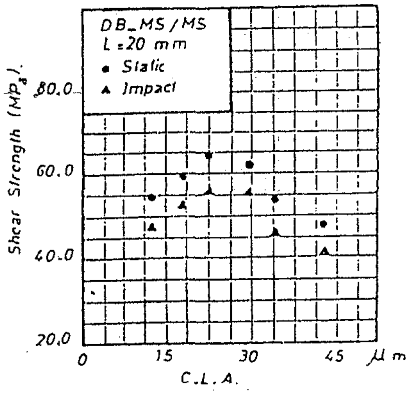


Fig.(8) Static and Impact Shear Strengths of (DB) Joints for Different Surface Roughness.

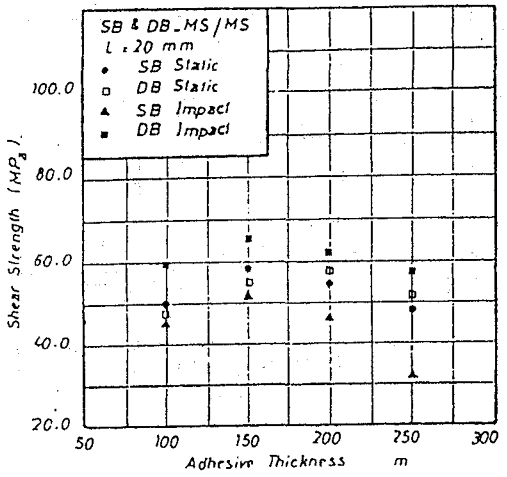


Fig.(9) Static and Impact Shear Strengths of SB, DB Joints for Different Adhesive Thickness.

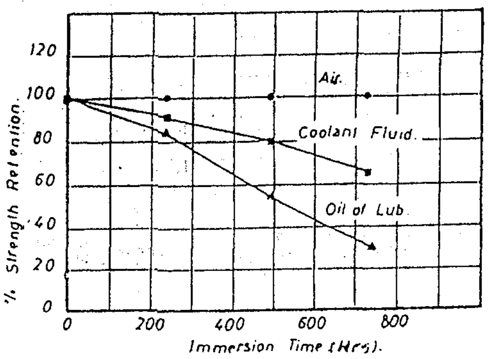


Fig.(10)[Change in Tensile Strength-Immersion Time] Relations For Different Hostile Environments.

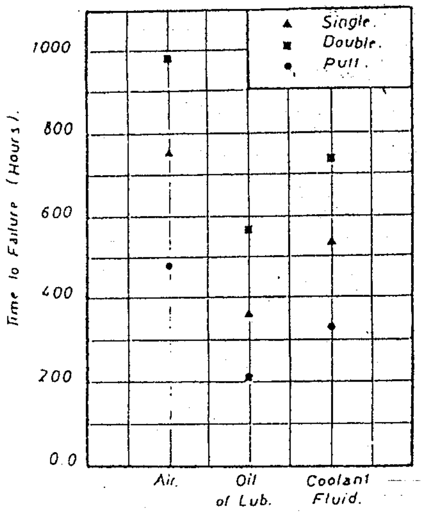


Fig. (11) Time to Failure of Mild Steel Joint Subjected Simultaneously to an Applied Tensile Stress in Different Environments.

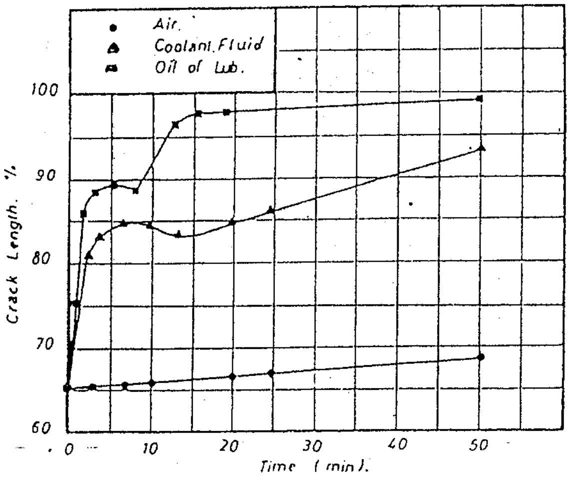


Fig.(12) Comparison of Mild Steel Joints Durability in Air, Coolant Fluid and Oil of Lubricant as Determind by Wedge Test.

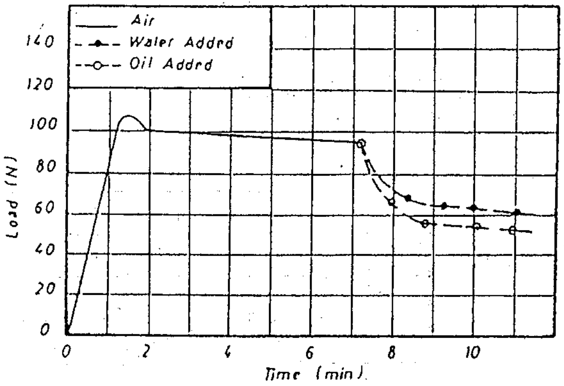


Fig.(13) Load Versus Time Trace Recorded During the Load Relaxation of MS Joint in Different HostileEnvironments.

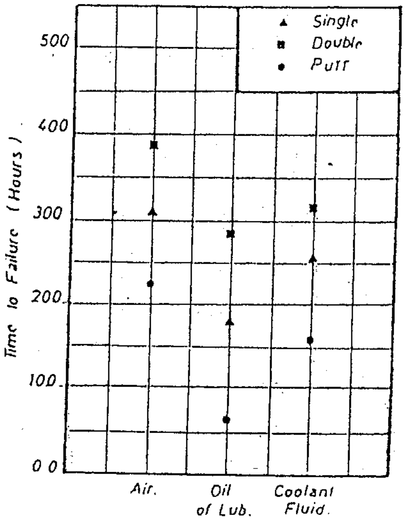


Fig.(14) Time to Failure of Mild Steel Joint Subjected Simultaneously to an Applied Torsion Moment in Different Environments.

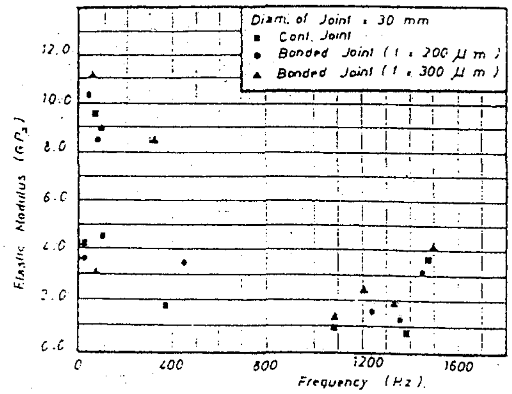


Fig. (15) Frequency Dependance on Elastic Modulus For (Fixed_Free Clamping).

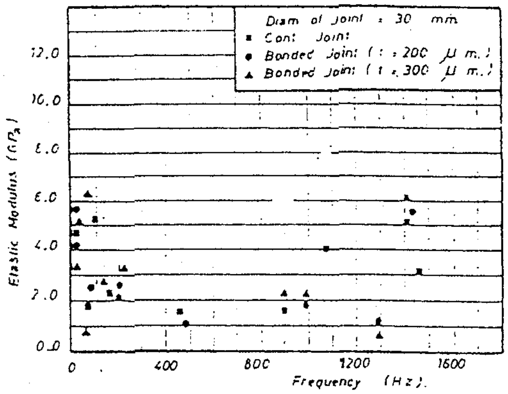


Fig.(16). Frequency Dependance on Elastic Modulus For(Fix_Fix Clamping).

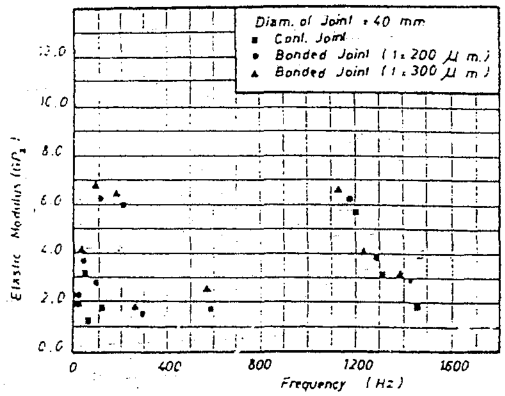


Fig. (17). Frequency Dependance on Elastic Modulus For(Fixed _Free Clamping).

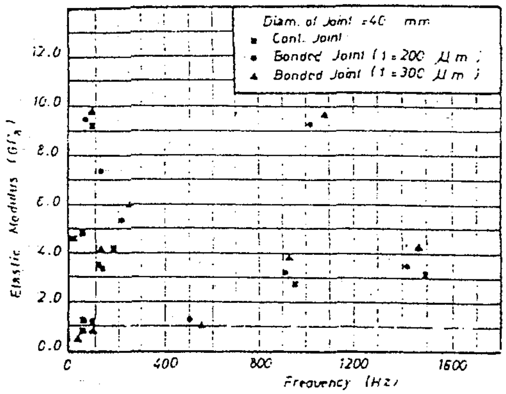


Fig.(18) Frequency Dependance on Elastic Modulus For (Fixed_Fixed Clamping).

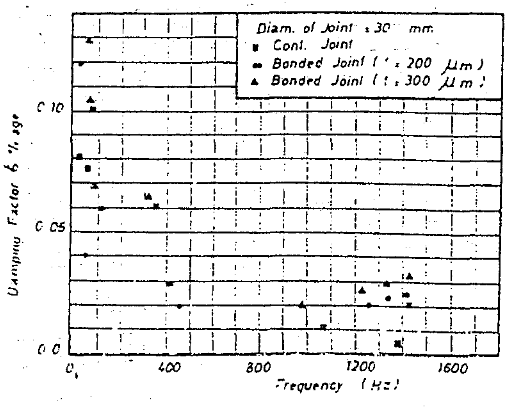


Fig.(19). Frequency Dependance on Damping Factor (Fixed_Free Clamping).

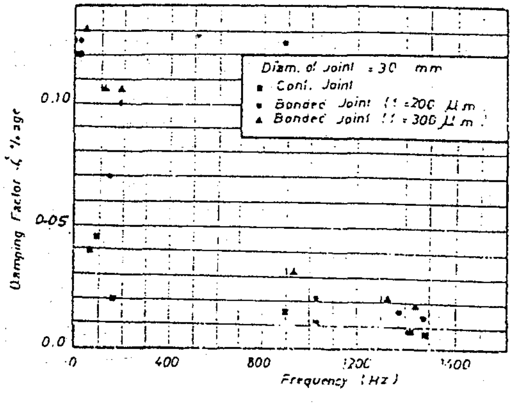


Fig.(20). Frequency Dependance on Damping Factor (Fixed_Fixed Clamping)

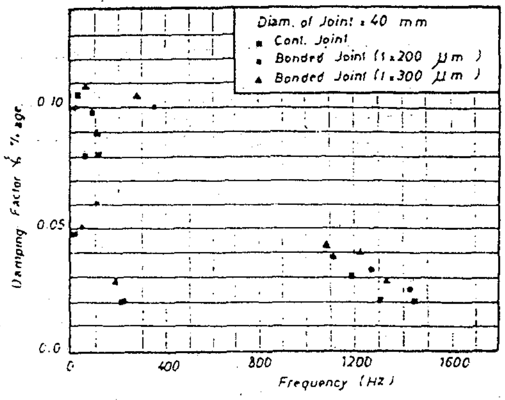


Fig.(21) Frequency Dependance on Damping Factor (Fixed_Free Clamping).

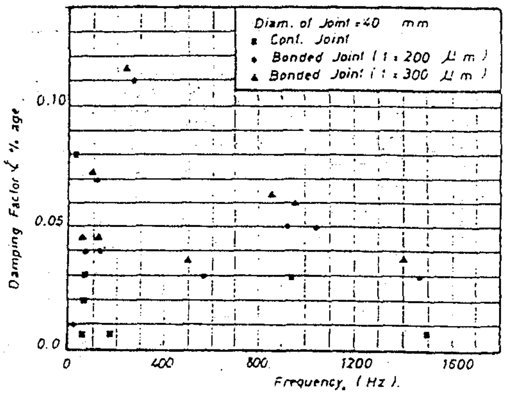


Fig.(22). Frequency Dependance on Damping Factor (Fixed_Fixed Clamping).

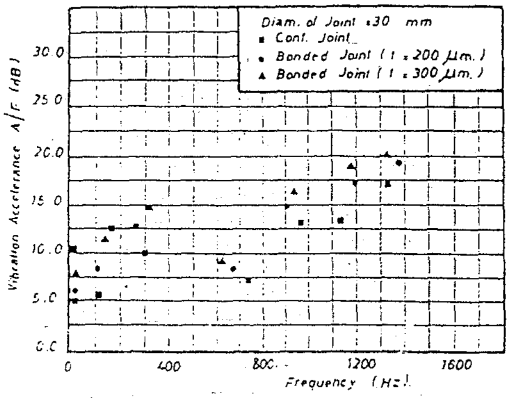


Fig.(23).Frequency Dependance on Vibration Accelerance (Fixed_Free Clamping).

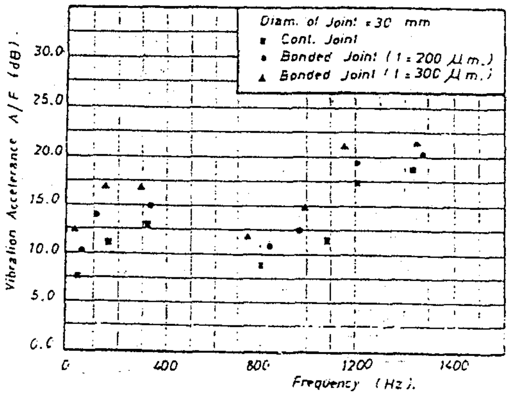


Fig.(24) Frequency Dependance on Vibration Accelerance (Fixed_Fixed Clamping).

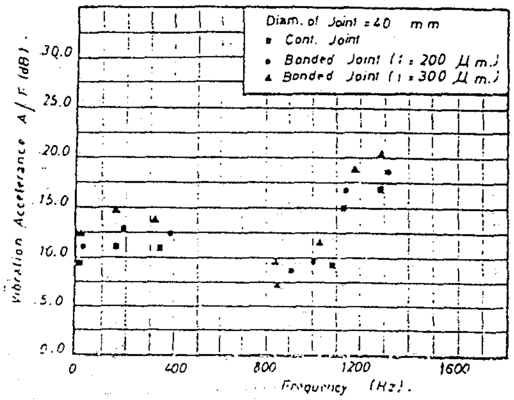


Fig (25) Frequency Dependance on Vibration Accelerance (Fixed_Free Clamping).

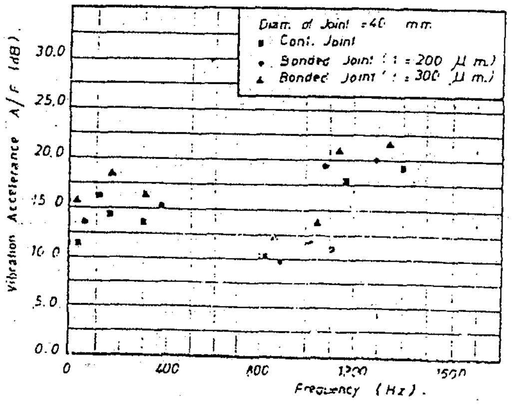


Fig.(26). Frequency Dependance on Vibration Accelerance (Fixed_Free Clamping).

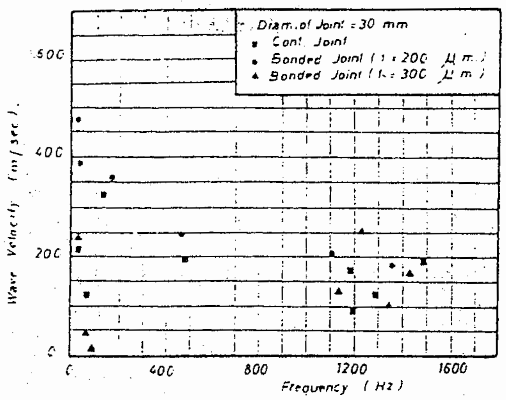


Fig.(27).Frequency Dependance on Wave Velocity (Fixed _ Fixed Clamping).

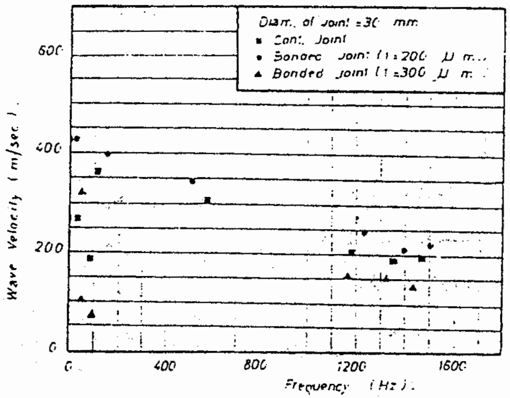


Fig.(28). Frequency Dependance on Wave Velocity (Fixed _ Free Clamping).

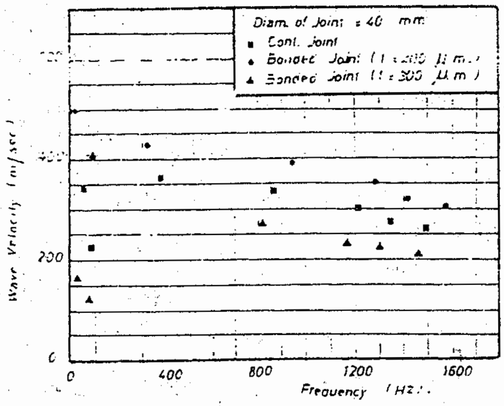


Fig.(29) Frequency Dependance on Wave Velocity (Fixed _ Free Clamping)

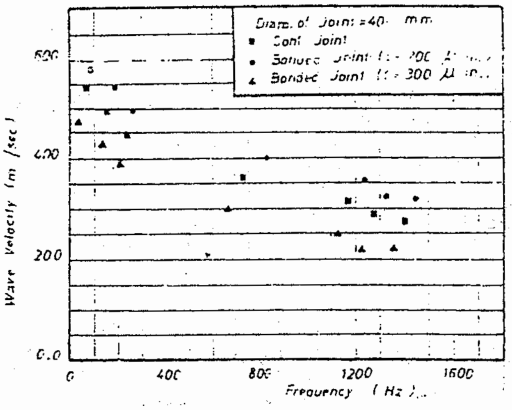


Fig.(30). Frequency Dependance on Wave Velocity (Fixed_Fixed Clamping).

عنوان البحث باللغه العربيه :

أداء المنشآت الملصوقة تحت ظروف عدائيه وإختبارات ديناميكيه

المشتركون : مفرد

ملخص البحث :

مع القصور الواضح في الاختبارات الديناميكيه لوصلات اللصق ونظراً لشيوع إستخدام هذه الطريقه في عمل الوصلات تم في هذا البحث دراسة تأثير كل مما يلي على تحمل نوعين من الوصلات الملصوقة لإجهاد الصدم وهذة العناصر هي : نوع المعدن الملصوق؛درجة خشونة السطح الملصوق للوصلة ، سمك المادة اللاصقه . وقد تم إستخدام نوعين من وصلات (Butt joint) إحداهما المفردة والأخرى المزدوجة – والمعادن المستخدمة في الوصلة هي Ms, Al(6061) بينما كان شريط الوصلة مصنعا من MS أوAl(6061) أو رقائق Polyester .

وفي هذا البحث أيضا تم إستخدام ثلاث طرق إختبار مختلفة وذلك للحصول على معلومات أكثر عن أداء وصلات اللصق في الظروف العدائية – هذه الطرق هي Wedge test, Tensile test وتم إستخدام Double Torsion test كطريقة مقارنة لتحسين ولزيادة المعلومات عن أداء هذا النوع من الوصلات في ظروف عدائية.

وقد تم في هذة الحالة تجهيز مجموعة من الوصلات (MS) وهذه الوصلات تم غمرها بالزيت وأخرى بسائل التبريد لأزمنة مختلفة، ومجموعة أخرى حملت أثناء غمرها في الظروف السابقة .

بالإضافة الى ذلك :-

تم في هذا البحث إستخدام تقنية الإهتزازه الصدمية لإجراء عمليات القياس لأداء الوصلة مستفيدين من النموذج التحليلي . ولقد أظهرت نتائج البحث أن العناصر المذكورة تلعب دوراً هاما في التأثير عى تحمل الوصلة سواء إجهاد الشد أو الصدم – ولكن وجد أن طول الشريط يلعب دوراً كبيراً في التأثير على تحمل الوصلة وخاصة عندما يكون قصيراً وعلى ذلك يكون من الضروري مراعاه الدقة في المقارنة بين التحمل الإستاتيكي والديناميكي لوصلات اللصق عندما يكون Lap length قصيراً.

ولقد أظهرت نتائج هذا البحث أن طريقة Short term test تمكننا من التنبؤ بزمن إنهيار الوصلة – وتوضح أيضاً تأثير الظروف العدائية على أداء ومستوى الإجهاد أثناء تحمل هذه الوصلات . ولقد أضاف إختيار D.T.T. معلومات ذات قيمة عن تحمل وصلة اللصق وأدائها.

ولقد أظهرت النتائج أن الوصلة ذات الشريطين Double Straps Joint تعطي أعلى قيم للتحمل في الظروف العدائية السابقة مقارنة بكل أنواع الوصلات التي تم إختيارها في هذا العمل.

وأيضاً أظهرت النتائج أن هناك تأثير لـ Frequency على الاخماد ومعاير المرونة المركب وسرعة الصوت في الوصلة الملصوقة ويعتمد ذلك أساساً على نسب المادة اللاصقة وأبعاد الوصلة.

مساهمة البحث في الصناعة :

هذا العمل غطى جوانب كثيرة للسلوك الاستاتيكي والديناميكي للوصلات الملصوقه وبالتالي يساعد المصممين عند التفضيل بين الوصلات عند معرفة الظروف المختلفه للتشغيل .