Determination of proper Adhesive Thickness and Overlap length for SS304

Gholap snehal s.
Dept.of Mechanical Engg.
S.V.I.T.Chincholi
Nasik,India
Snehal.gholap01@gmail.com

Prof.Shelke R.S.
Dept.of Mechanical Engg.
S.V.I.T.Chincholi
Nasik,India
rssme@rediffmail.com

***Abstract*—Now a days there is one common technique which is used for joining two materials that is by using Adhesive. This adhesive joining process is used in various purposes and we are selecting this for Aerospace purpose. We are using this process for joining two same Aherant.We are using Aherant as SS304 and Adhesive as LOCTITE EA-30HV.We are joining that Aherant by using Adhesive by using it's procedure. We are selecting Adhesive layer thickness by the properties of that adhesive after joining that adherent we are using Universal testing machine for determination proper adhesive thickness and proper overlap length. We are validating that results by using ANSYS.**

***Keywords:*-Adhesive, Adherant, UTM, ANSYS, LOCTITE**

I. Introduction

Adhesive bonding is a material joining process in which an adhesive, placed between the adherend surfaces, solidifies to produce an adhesive bond .When we bond components together the adhesive first thoroughly wets the surface and fills the space between and then it solidifies. When solidification is completed the bond can withstand the stresses of use. The strongest adhesives harden through chemical reaction and have a pronounced affinity for the joint surfaces. Adhesives come in several verities of thin liquids, thick pastes, films, powders, pre-applied on tapes, or solids that must be melted. Now a day's adhesive compete with mechanical fastening systems such as nuts, bolts, and rivets, or welding and soldering.

Epoxy adhesives consist of an epoxy resin plus a hardener. Upon cure, epoxies typically form tough, rigid thermo-set polymers with high aprobacion to a multitude of substrates and superior environmental resistance. By using a two-part system, the resin & hardener are packaged separately and are mixed just prior to use. This allows more active hardeners to be used in order that the two-part epoxies will rapidly cure at ambient conditions

The composite structural users are highly used in the following applications such as aerospace, automobiles, marine, architecture etc., has drawn comprehensive attention in past times. Adhesive bonding is a practical joint method for joining composite materials though low shear & tensile strength limit the joint efficiency. A numerical and experimental study was carried out to detect the ultimate strength & failure modes of bonded- single lap joints at two different overlap width areas. In the present work,tensile strength of lap joint.. Adhesive composite joints nowadays play an important role in aerospace, wind generator and ship designs. Exact failure predictions are required for efficient joint design and to utilize the features of adhesive bonding, for example a more uniform stress distribution in the joint area, or less weight of total structure in comparison with mechanical fasteners.

Total materials used in 778 body, in that body 20%Aluminum is used, 15%titanium is used, 10% steel is used and 5% other material is used and 50%composites are used. By comparison the 777 uses 12% composites and 50% aluminum. As aluminum and steel is used more in aerospace purpose we are selecting steel for our experimentation purpose. Manufacturing large & complex structures is usually possible only when they are composed of assemblies of small part joined together by various joining techniques since in most of the product we cannot produces that as single piece.

II. LITERATURE REVIEW

HE Dan Toshiyuki SAWA Atsushi KARAMI states that, the stress allocation in the important joints with dissimilar adherends exposed to static bending moments were calculated using the FEM code ANSYS in the both two dimensional and three dimensional cases. In addition, the rupture bending moment was predicted. The effect of Young's modulus of the adhesive, regarding the adherends and the thickness of the adhesive layer on the inner surface stress distributions was investigated with the 3-D FEM data. The results show that the stress variation at the edges of interfaces decreases as the Young's modulus of raises increases, the ratio of Young's modulus to raises is decreases, and the thickness of adhesive layer decreases. The rupture bending moments were estimated using both the maximum principal stress failure criterion and the maximum principal strain failure criterion in 3-D FEM calculations in elastoplastic deformation range. The rupture bending moments estimated using the maximum principal strain failure criterion were in good agreements with the experimental results.

Y. B. Patil, R. B. Barjibhe In this work modal analysis of bonded beams with an individual lap epoxy adhesive joint of plates are investigated. The three specimen are used which are made up of Al-Al plates, Cu-Cu plates and Ms-Ms plates. Ansys 11.0 finite element software is used for modal analysis of single lap joint. The results show that the natural frequencies are directly proportional to the Young's modulus and Occurrence ratio. It is deduce that the FEA of dynamic response of the beams with a single lap joint will help future applications of adhesive bonding by taking different parameters are selected for as large as a process window as possible for bonded beams examination.

Solyman Sharifi, and Naghdali Choupani states that
the behavior of adhesively bonded joints subjected to combined thermal loads, by testing numerically. The joint configuration considers aluminum as central adherend with more different adherends consisting aluminum, titanium, steel, boronepoxy, unidirectional graphite-epoxy and cross-ply graphite-epoxy & epoxy adhesives. Free expansion of the joint in x direction was permitted and stresses in adhesive layer and interfaces computed for different adherends. The effects of adherends on the stresses were studied using double-lap joint. The middle adherend is aluminum & the adhesive is FM®73. Cracks always initiated in the fixed end into above and below adherends in the cases which upper and lower adherend prepared by isotropic material. Therefore the stiffer adherend causes to a decrease in strength of the joint.

Yinhuan Yang states that On the basis of the present experimental results and considering five sorts of failure modes, failure prediction of adhesively bonded single lap joints with adherend thickness 0.3m, adherend thickness 0.2m and defect in the adhesive layer under uni-axial tensile loading is performed by inability failure method. The numerical methods of composites adhesive joints implemented in ANSYS (APDL) with commercial finite element codes ANSYS. The initiation of adhesive failure and interfacial shear failure is discovered in both ends for joints with adherend thickness 3 mm and 2 mm, adhesive failure is expanded fast along the lap-length direction with the increasing load until ultimate failure is emerged. The initiation of damage for the joint with defect in the adhesive layer is broken out around the defect, and damage area around the defect connected with interface crack by the overlap end lead to the eventual failure. Stress values in the bonding interface is much greater than them in the mid-surface of the adhesive layer predict for out-of-plane stress x z τ and yz τ . It is easier relatively that interface failure is occurred. Further, it is found that stress concentration is all present near the 1.25mm on the overlap zone ends, which is the initial point of damage.

Mr. Gajanan M. Kulkarni, Prof. B. D. Gaikwad This paper demonstrates how Finite Element Method helps to check out the strength of hybrid joint made up of Adhesive & Rivets in Steel Double Lap Joint specimen. Also the paper will showcase the impact of adhesive composition (Resin to Hardner ratio) on force sustained by joints. From FEA analysis The Maximum Deformation obtained between three casesis 0.63 mm in Hybrid Joint in comparison with rivetand and Adhesive Joint. This indicates Maximum sustainability of that Joint.The Max. Von Misses Stress obtained amongst three cases is 580.75 Mpa in Hybrid Joint in comparison with rivet and Adhesive Joint. This kind of proves Maximum sustainability of that Joint

III.OBJECTIVE

Objective of this project is to find optimum overlap length and optimum overlap thickness. We are considering range of overlap length and overlap thickness and then by using Experimental method we are finding optimum overlap length and optimum overlap thickness. Then validation has to be carried by using a finite element method.

IV.METHODOLOGY

The goal of experimental work is to find the optimum overlap length and optimum overlap thickness for the joint in which adherent is SS304 and adhesive is Loctite EA E-30HV. The selection of overlap length is on the basis of L'/W ratio should be in between 1.5to 2.

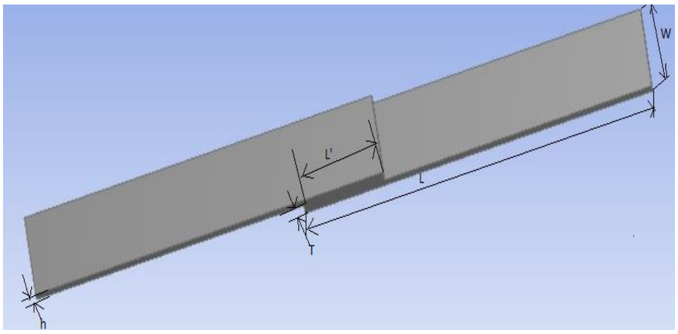

Fig.1Adhesive Joint

There are two Specimens Which is made up of SS304 having dimensions130*30*1.95(L*W*T) & which are joint by Adhesive LOCTITE EA E-30 HV as shown in fig.1.We are joining that strips with that adhesive by using Adhesive dimensions and by using its procedure. We choose that adhesive thickness in between 1 to 2mm because it is showing optimum results in that range, also we select overlap length by using criteria L'/w should be in between 1.5 to2. When that joint become strong after that we test that specimen on Universal testing machine. We fix one end of specimen on one jaw and next to the moving jaw and then we apply tensile force. We apply force up to its ultimate tensile limit. After that we test all nine specimens.

A.BY USING ANSYS

Now we will verify that results by using ANSYS.
By using UTM results we got load carrying capacity of that material and Adhesive. We are just distribute that force in no of parts so that we can see von-misses stress variation and deformation variation

Material Properties used in Ansys

Table no I. Properties of Adhesive and adherent

Properties	Adhesive	Adherent
Young's Modulus,E_0	193 Gpa	7960N/mm^2
Poisson's ratio v	0.35	0.29

Boundary Conditions:-

By using boundary conditions we can define forces on specimens, which are as shown in table.

Table no II.Boundary conditions

Speci. no	Dimensions	1st end Condi.	End condition(2ndend)
1	T=1 & L=30	Fixed	500,1000,2000N
2	T=1 & L=60	Fixed	500,1000,2000,4000N
3	T=1.5 &L=30	Fixed	500,1000,2000,4000,5000N
4	T=1.5 &L=60	Fixed	500,1000,2000,4000,6000N
5	T=2 & L=30	Fixed	500,1000,2000N
6	T=2 & L=60	Fixed	500,1000,2000N
7	T=1.5 &L=15	Fixed	500,1000,2000N
8	T=2 & L=15	Fixed	500,1000,2000,4000N
9	T=1 & L=15	Fixed	500,1000,2000N

We apply all these boundary conditions to the Adhesive joint and we calculate Von-misses stress and deformation. By giving these end condition we are getting Ansys results follows

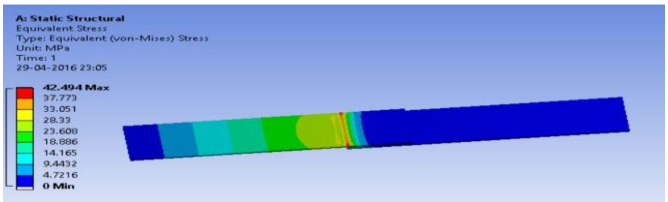

Fig.2 von-misses stress for (T=1mm, L=30mm) at 2000N load

For fig 2max von-misses stress is 42.494 mpa i.e. at the start of the adhesive joint.

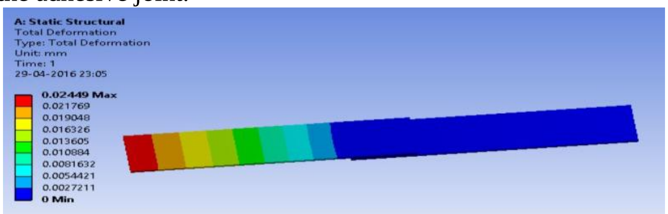

Fig.3 Deformation for (T=1mm, L=30mm) at 2000N load

For fig 3 maximum deformations is 0.02449mm and it is at the starting point of the strip.

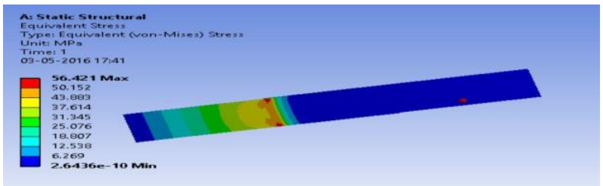

Fig.4von-misses stress for(T=1mm, L=60mm) at4000N load

For fig 4 max von misses stress is at the start point of the joint and it is 56.421mpa and it is varying as shown in fig.

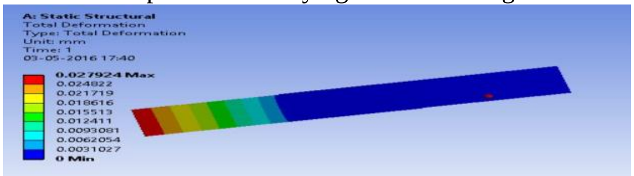

Fig.5 Deformation for (T=1mm, L=60mm) at4000N load

For fig.5 max. Deformation is 0.02794mm and it is at start and it is for T=1mm, L=60mm and for 4000N load.

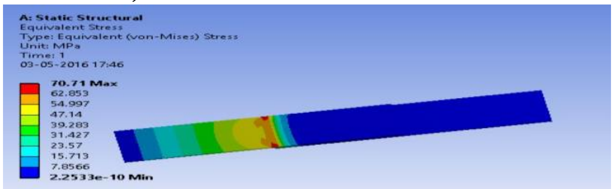

Fig.6Von-misses stress for T=1.5,L=30mm at 5000Nload

For fig 6 at T=1.5,L=30mm for the loading condition 5000N max von-misses stresses are 70.71mpa and it is at the starting point of the joint .

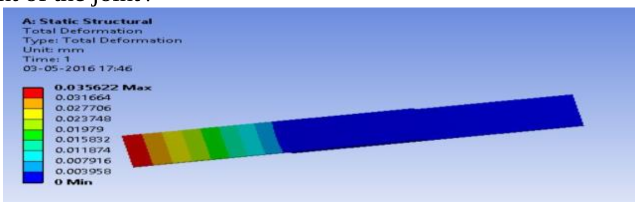

Fig.7Deformetion for T=1.5, L=30mm at 5000N load

For fig 7 at T=1.5, L=30mm for the loading condition 5000N max Deformation 0.035622mm and it is at the starting point of the strip.

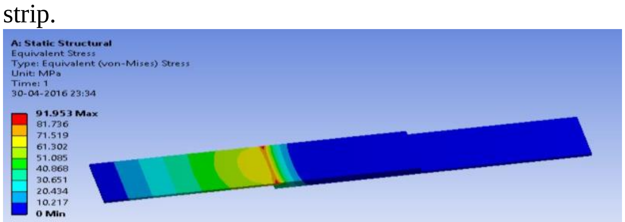

Fig.8Von-misses stress for T=1.5, L=60mm at 6000N load

For fig 8 at T=1.5,L=60mm for the loading condition 6000N max von misses stresses are 91.953mpa and it is at the starting point of the joint .

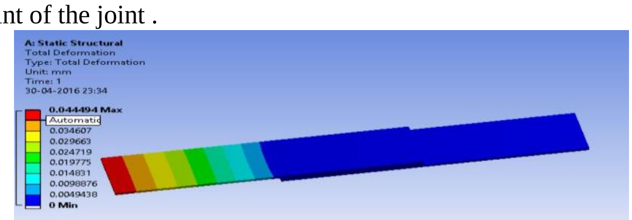

Fig.9Deformetion for T=1.5, L=60mm at 6000N load

For fig 9 at T=1.5, L=60mm for the loading condition 6000N max Deformation 0.04449mm and it is at the starting point of the strip.

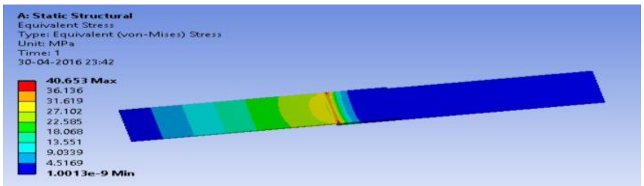

Fig.10Von-misses stress for T=2, L=30 at 2000N load

For fig 10 at T=2,L=30mm for the loading condition 2000N max von misses stresses are 40.653mpa and it is at the starting point of the joint .

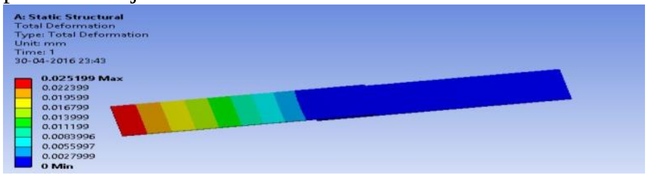

Fig.11Deformetion for T=2, L=30mm at 2000N load

For fig 11 at T=2, L=30mm for the loading condition 2000N max Deformation 0.025195mm and it is at the starting point of the strip.

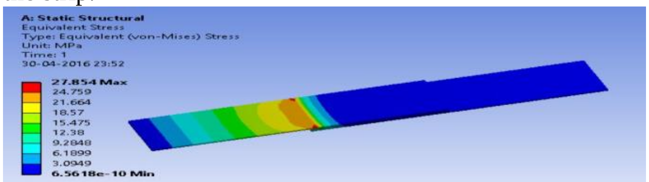

Fig.12Von-misses stress for T=2, L=60mm at 2000N load

For fig 12 at T=2,L=60mm for the loading condition 2000N max von misses stresses are 27.854mpa and it is at the starting point of the joint .

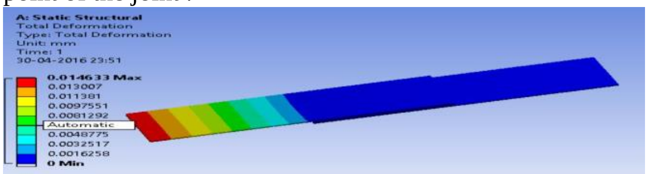

Fig.13Deformetion for T=2, L=60mm at 2000N load

For fig 13 at T=2, L=60mm for the loading condition 2000N max Deformation 0.014633mm and it is at the starting point of the strip.

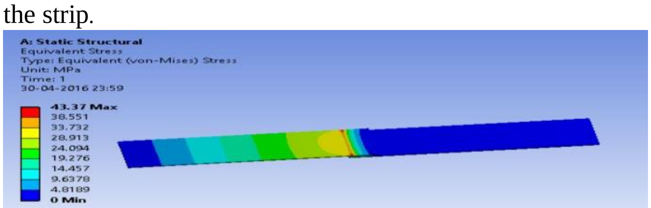

Fig.14Von-misses stress for T=1.5,L=15mm at 2000N load

For fig 14 at T=1.5,L=15mm for the loading condition 2000N max von misses stresses are 43.37mpa and it is at the starting point of the joint .

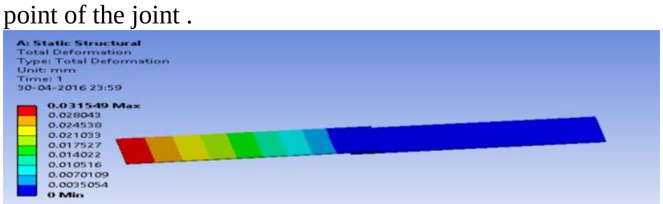

Fig.15Deformetion for T=1.5, L=15mm at 2000N load

For fig 15 at T=1.5, L=15mm for the loading condition 2000N max Deformation 0.031549mm and it is at the starting point of the strip.

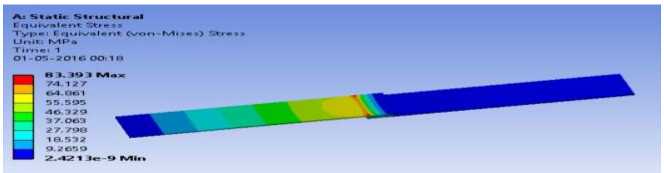

Fig.16Von-misses stress for T=2, L=15mm at 4000N load

For fig 16 at T=2,L=15mm for the loading condition 4000N max von misses stresses are 83.393mpa and it is at the starting point of the joint

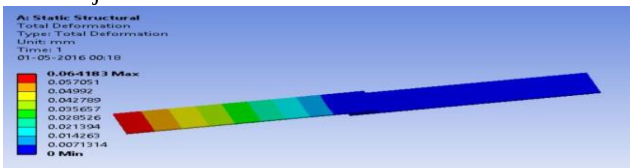

Fig.17Deformetion for T=2, L=15mm at 4000N load

For fig.17 at T=2, L=15mm for the loading condition 4000N max Deformation 0.035622mm and it is at the starting point of the strip

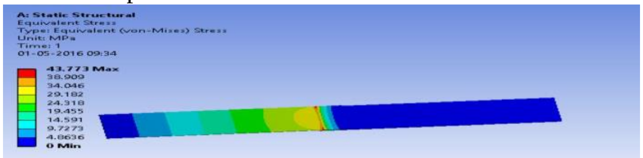

Fig.18 Von-misses stress for T=1, L=15mm at 2000N load

For fig 18 at T=1,L=15mm for the loading condition 2000N max von misses stresses are 43.773mpa and it is at the starting point of the joint .

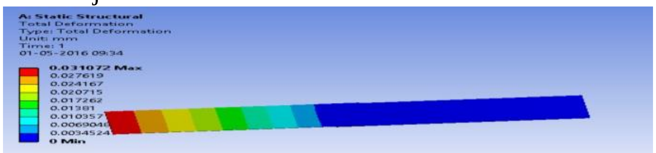

Fig.19 Deformation for T=1,L=15mm at 2000N load

For fig 19 at T=1, L=15mm for the loading condition 2000N max Deformation 0.031072mm and it is at the starting point of the strip. By using all these fig. we can find maximum stress and maximum deformation on the joint with their respective loading condition.

VI.RESULT AND DISCUSSION

When we test the specimen on UTM it is showing readings as showing in the table no III

Table no.III.Readings by using UTM

Speci. No	Propertiesof Adhesive		Strength by using UTM	Von-misses stress(σ_v)mpa
	Overlap Length (L)	Overlap Thickness (T)		
1	30mm	1mm	2780N	92.66
2	60mm	1mm	4800N	160
3	30mm	1.5mm	5180N	115.11
4	**60mm**	**1.5mm**	**7000N**	**155.56**
5	30mm	2mm	2380N	39.667
6	60mm	2mm	2000N	41.67
7	15mm	1.5mm	2560N	56.89
8	15mm	2mm	4160N	69.33
9	15mm	1mm	3080N	102.66

In that results we can get strength of respective specimen and von-misses stress of those specimens by observing that we can say that specimen no for is better as is having more strength and von-misses stress.

Table no.IV. Readings by using Ansys.

Specimen No	Dimensions	Force (N)	Stress (mpa)	Deformation (mm)
1	T=1 & L=30	500	10.624	0.0061
		1000	21.247	0.012245
		2000	42.494	0.02449
2	T=1 & L=60	500	7.6728	0.0036415
		1000	15.346	0.007283
		2000	30.402	0.014566
		4000	56.421	0.027924
3	T=1.5 & L=30	500	7.6006	0.003768
		1000	15.201	0.007536
		2000	30.402	0.015074
		4000	60.804	0.030147
		5000	70.71	0.035622
4	T=1.5 & L=60	500	7.6628	0.003707
		1000	15.326	0.0074157
		2000	30.651	0.014831
		4000	61.302	0.029663
		6000	**91.953**	**0.04449**
5	T=2 & L=30	500	10.163	0.00629
		1000	20.326	0.012599
		2000	40.653	0.025195
6	T=2 & L=60	500	6.9636	0.003658
		1000	13.927	0.0073163
		2000	27.854	0.014633
7	T=1.5 & L=15	500	10.842	0.00788
		1000	21.685	0.01577
		2000	43.37	0.031549
8	T=2 & L=15	500	10.424	0.00802
		1000	20.848	0.01604
		2000	41.696	0.032091
		4000	83.393	0.035622
9	T=1 & L=15	500	10.943	0.0077679
		1000	21.886	0.015536
		2000	43.773	0.031072

By using that strength we can select boundary condition for all specimens so that we can apply it on all specimens in ANSYS. When we apply all boundary condition to the specimens and find von-misses stress and deformation it is showing results as shown in table IV. In that also specimen no four is better as it is having max von-misses stress and deformation.

VII.CONCLUSION

If we compare both the results as shown in the table no III,in that table all the results by using UTM, we are getting tensile strength and Von-misses stress, in that results for specimen no four we are getting best results for overlap length 60mm and overlap thickness 1.5mm strength as 700N and Von-mises stress155.56mpa which are maximum.

Also as showing in the Table IV,in that table we are getting all the results by using ANSYS in that the results are Von misses stress and deformation. In that results for specimen no four i.e. for overlap thickness 1.5mm and for overlap length 60mm we are getting maximum Von misses stress as 91.953mpa and deformation as 0.04449mm.

By observing both these results we can say that when we have to join two plates (130*30*1.95mm) of SS304 by using Adhesive EA-E30HV in that case overlap length should be 60mm and overlap thickness should be 1.5mm,.as we observe that results which we are getting from UTM and ANSYS i.e. stresses and deformation are increasing up to certain limit and then it will reach up to some highest value and again the stress and deformations are decreasing .

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I would like to express my sincere thanks to all members who are directly or indirectly part of this work.

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