Suspension Clevises

ARG25 Fall Technical Report
December 15, 2024
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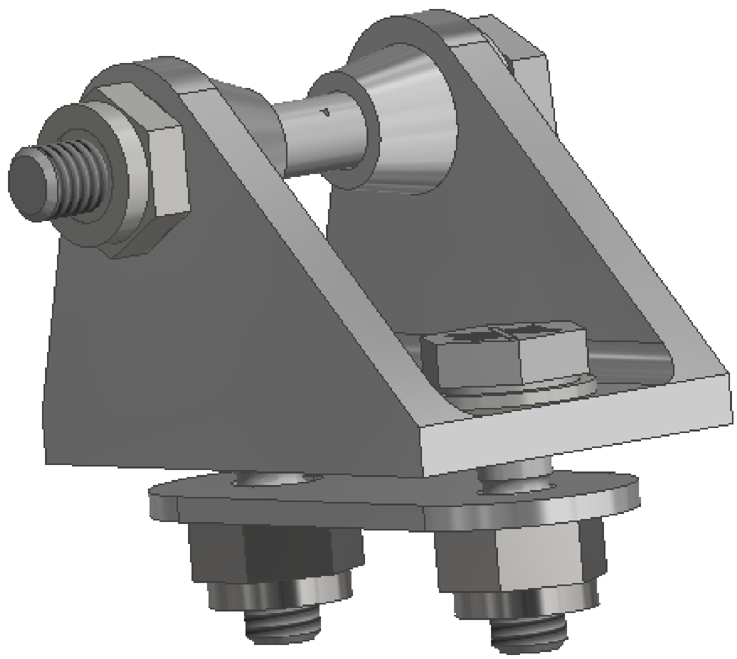

Subteam: Suspension
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Team: Chassis
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0. Introduction (10)

The primary function of the suspension clevises is to serve as the interface between the suspension links and the monocoque and the suspension links and the uprights. Since the clevises are part of the load path between the ground and the chassis, it is critical that they can withstand the maximum load cases experienced by each respective link and transfer that force into the monocoque.

The clevis itself is U-shaped and has two holes on either clevis wall, aligned so that a bolt can pass through to act as a clevis pin. The clevis pin allows the spherical bearing at the end of a suspension link to be interfaced with the clevis. The clevis pins are mounted in double shear, and feature bushings that we refer to as “cones”. These are included to restrict the axial movement of the spherical link bearings. The suspension clevises also have mounting holes that allow it to be bolted to the monocoque.

ARG25 RLR-Clevis Side View

Included below is the set of rules associated with the suspension clevises. There are relatively few rules associated with the clevises and they remain consistent each year:

V - VEHICLE REQUIREMENTS
V.3 SUSPENSION AND STEERING
V.3.1 Suspension
V.3.1.3 All suspension mounting points must be visible at Technical Inspection by direct view or by removing any covers.
V.3.1.4 Fasteners in the Suspension system are Critical Fasteners, see T.8.2
V.3.1.5 All spherical rod ends and spherical bearings on the suspension and steering must be one of:

- Mounted in double shear

- Captured by having a screw/bolt head or washer with an outside diameter that is larger than spherical bearing housing inside diameter.

T – TECHNICAL ASPECTS

T.8 FASTENERS

T.8.1 Critical Fasteners

A fastener (bolt, screw, pin, etc) used in a location specified in the applicable rule

T.8.2 Critical Fastener Requirements

T.8.2.1 Any Critical Fastener must meet, at minimum, one of these:

a. SAE Grade 5
b. Metric Grade 8.8
c. AN/MS Specifications
d. Equivalent to or better than above, as approved by a Rules Question or at Technical Inspection

T.8.2.2 All threaded Critical Fasteners must be one of the two:

- Hex head
- Hexagonal recessed drive (Socket Head Cap Screws or Allen screws/bolts)

T.8.2.3 All Critical Fasteners must be secured from unintentional loosening with Positive Locking Mechanisms see T.8.3
T.8.2.4 A minimum of two full threads must project from any lock nut.
T.8.2.5 Some Critical Fastener applications have additional requirements that are provided in the applicable section.

T.8.3 Positive Locking Mechanisms

T.8.3.1 Positive Locking Mechanisms are defined as those which: a. Technical Inspectors / team members can see that the device/system is in place (visible). b. Do not rely on the clamping force to apply the locking or anti vibration feature. Meaning If the fastener begins to loosen, the locking device still prevents the fastener coming completely loose

1. *Technical Overview (don't explain your design yet, and do not carry out any analytical methods) (20)*

There are many failure modes that should be considered when designing suspension clevises. These can be categorized into 4 main areas and are outlined in the table below:

Bolted Monocoque/ Upright Interface	Failure of Clevis Pin	Lug Walls	Bearing Failure of Cones
- Bolt shear failure - Bolt tensile failure	- Bolt double shear	- Tensile loading - Compressive loading - Buckling	- Clevis pin-cone interaction - Cone-lug bore interaction

Summary of the Four Main Clevis Failure Modes

All the above failure modes are analyzed with respect to the maximum compressive and tensile forces experienced be each clevis' respective link, which are the primary design parameters.

Before discussing these in detail, it is important to understand the components of the link loads that contribute to each failure.

The links can apply a uniaxial load in either compression or tension on the clevis and different failure modes can occur from the axial and transverse components of these loads. For clevis analysis, the axial direction is defined as orthogonal to monocoque surface, and the transverse direction is parallel to the monocoque as shown below:

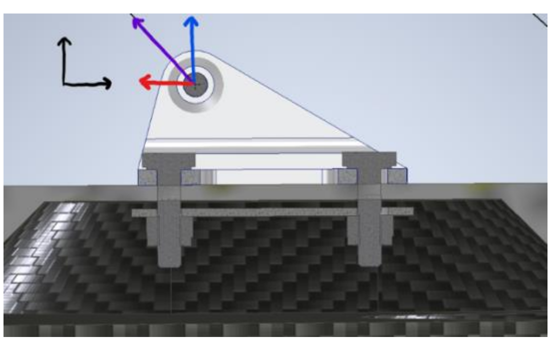


Fig. 1 Tensile loading of a Clevis [11]

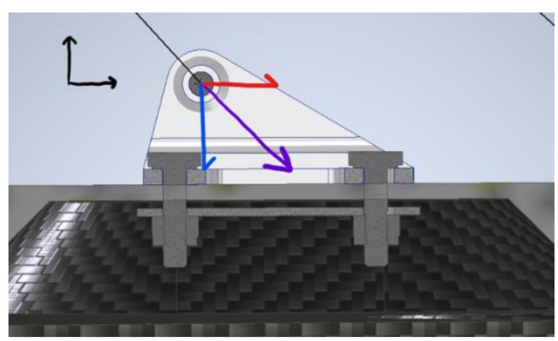


Fig. 2 Compressive loading of a Clevis [11]

In the above diagrams the axial loads are shown blue and the transverse loads are shown in red. To calculate the axial and transverse components, trigonometry can be used with the angles that each load path makes with the monocoque surface. These angles can be measured from the Suspension Master CAD.

Bolted Monocoque/Upright Interface:

The inboard and outboard clevises mount to the monocoque and uprights respectively. Here there are two main possible failure modes: bolt shear and bolt tensile failure.

Bolt shear failure:

Bolt shear occurs when a significant force is applied over the diameter of the bolt. In the case of the clevises shear stress is created by the transverse loads. Failure will occur when the shear stress acting on the area of the bolt exceeds the shear strength of the bolt material. Since the transverse loads can be either compressive or tensile, the higher of these two values should be considered when analyzing this failure mode. [1]

Due to one of mounting holes being slotted, we assume that only one bolt is carrying the shear load of the entire clevis. Clevis designers should make sure that the transverse loading does not exceed the rated yield stress for that clevis' sized AN bolt. Material properties for AN spec bolts are located on the S: Drive and referenced at the end of this report.

Bolt Tensile Failure:

Bolt tensile failure for most clevises is a more likely mode of failure since, most of the loads are distributed axially through the clevis. In contrast to analyzing for shear failure, we assume that both bolts carry the tensile loading, and so bolt tensile failure occurs when a tensile axial load applied to the clevis exceeds the combined preload of the two interface bolts. In the same document of material properties, preloading and yield strength of AN bolts can be found in the S:Drive. [15]

Failure of Clevis Pin

The second area of potential failure is the failure of the clevis pin. For the suspension clevises, a bolt runs through two holes in the clevis walls. This clevis pin is analysed in double shear to ensure that it can withstand the loads from the links.

Failure of Lug Walls:

For our analysis of the clevis lug walls, we assume that only one clevis lug carries all the load. This is because the loads applied to the clevises are not always orthogonal to the monocoque/upright because the link pivots up and down when the car moves.

MechaniCalc, an online analysis tool for mechanical and structural analysis, lists the following as modes that can occur on a lug from tensile loading [3]:

- Tension failure across the net section
- Shear failure along two planes
- Bearing failure
- Hoop tension failure/fracture on single plane
- Buckling

For previous clevis designs, the team has used the Air Force Model (AFM) as it considers most of the above failures, with the exception of buckling, and allows analysis for lugs under axial and transverse loading. Furthermore, the AFM accounts for the interaction between the clevis pin and the lug.

This year, we decided to continue the use of MechaniCalc's lug calculator, which uses the AFM. The software outputs the lug strength for oblique loading which can be used to find margin of safeties for the suspension load cases.

The only drawback of Mechanicalc and the AFM is that it only analyses lug strength under tensile loading. To analyze compressive lug strength, Sohum Kulkarni, ARG22's clevis designer, created a MATLAB script called 'lugcalc.m' [5]. I would advise any future designer to look and understand how the script was developed by reading Sohum's ARG22 Fall Technical Report. The script outputs the margin of safeties for compressive lug strengths which any part designer should aim to keep over 0. For ARG25, I modified the script to include some more materials, such as Al-T7351.

As mentioned before the AFM model does not consider buckling of the lugs. Since the clevis walls are fairly short compared to their thickness, the clevis walls are considered to be intermediate columns. Therefore, they do not follow the ideal Euler buckling equation and instead the Johnson Buckling equation should be used:

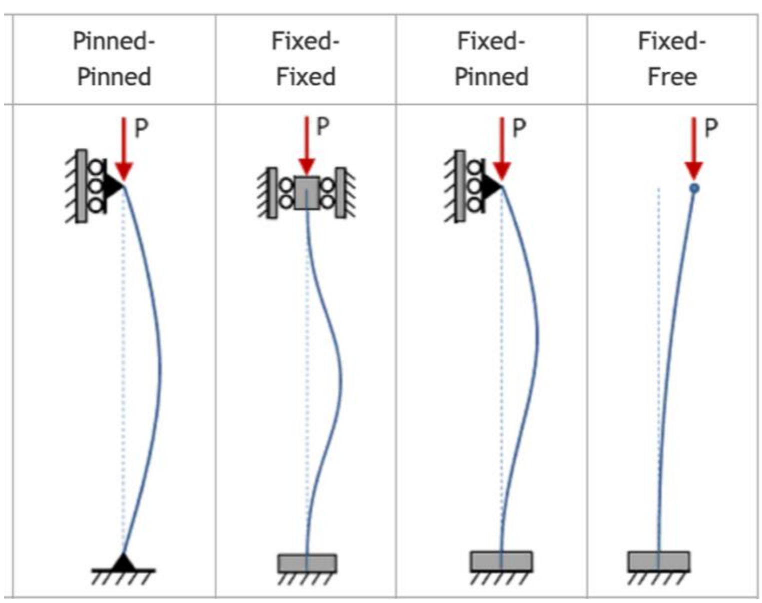
$$\sigma_{crit} = \sigma_{yield} - \frac{1}{E}\left(\frac{\sigma_{yield}}{2\pi}\frac{KL}{r}\right)^2$$

Where,

- σ_{crit} is the stress required to produce buckling
- σ_{yield} is the yield stress of the material

- E is the elastic modulus of the material
- K is the effective length factor dependent on end constraints
- L is the length of the beam
- r is the radius of gyration

For our analysis, since there are no reactionary forces or moments restricting the movement of the top end of the column, we classify the lug as a fixed-free column, where K is approximately 2.



End Conditions of Column's (MechaniCalc) [6]

Bearing Failure of Cones

Finally, there are two main ways that the cones can cause failure. The cones in a clevis assembly are bushings that fit into the bores in the clevis wall and act to restrict the movement of the spherical bearings along the clevis pin.

When the clevis undergoes a load, the outer diameter of the cone presses into the bore of the clevis and the clevis pin also presses into the inner diameter of the cone. This contact pressure between the different parts of the assembly causes bearing stress which can be calculated by dividing the force perpendicular to the bore by the projected area of the bore.

$$f_{br} = \frac{P}{Dt}$$

Where,

- f_{br} is the bearing stress

- P is the applied force
- D is the diameter of the bore
- t is the thickness of the bore

Since failure could occur at either the interaction between the cone and the pin or the cone and the lug wall, both should be analysed separately. When considering the t, the thickness of the bore:

For the cone/pin interaction:
- Use the length of the cone that is in contact with the pin i.e. the inner height of the cone

For the cone/bore interaction:
- Use the length of the cone that is in contact with the clevis wall i.e. the clevis wall width

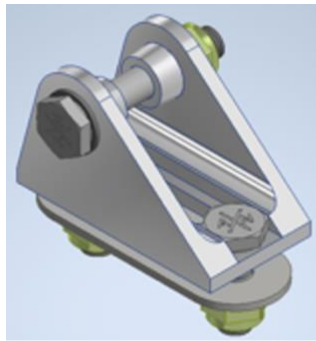
Other Teams:
Clevises are common among FSAE teams who run a carbon fiber monocoque similar to our own. However, teams running with a tube frame typically weld tabs to act a mounting point on the frame as shown below from the University of Windsor's 2020 FSAE car.

2020 University of Windsor FSAE, demonstrating square tubing directly welded to the round tubes of the frame. [16]

2. History of Past Designs (don't explain your design yet) (10)

Ever since turning to a carbon fiber monocoque in 2010, Cornell Racing have utilized clevises as a way of mounting the suspension links to the car. In the years since this change, the design of the clevises has remained relatively consistent.

The first major change of the design of a clevis was made for ARG19, where a bolt capture slot was introduced to the base of the clevis for easier bolt access during assembly. The main motivator for this decision was that by removing the need to fit a tool inside the clevis the width could be reduced considerably. However, the slot at the base did add weight to the design.



ARG23 FP Clevis with Bolt Capture Slot [11]

Furthermore, it is important to acknowledge that the suspension clevises should follow a “mount and forget” philosophy - meaning once the clevises are devcon’d and mounted to the monocoque, they should not need to be taken off the car. Therefore, the bolt capture slot was removed for ARG24 as the added weight was not enough to justify “ease of access”.

Whilst there have been very few failures in previous clevis designs, there has previously been the need to redesign clevises after finding issues midway through manufacturing/integration. For instance, for ARG21, the FLF clevis needed to be redesigned to accommodate the rod ends as they did not have enough clearance with the mounting bolts. After the first redesign it was also found that the rod end was slightly larger than the CAD, so they had to be redesigned for a second time.

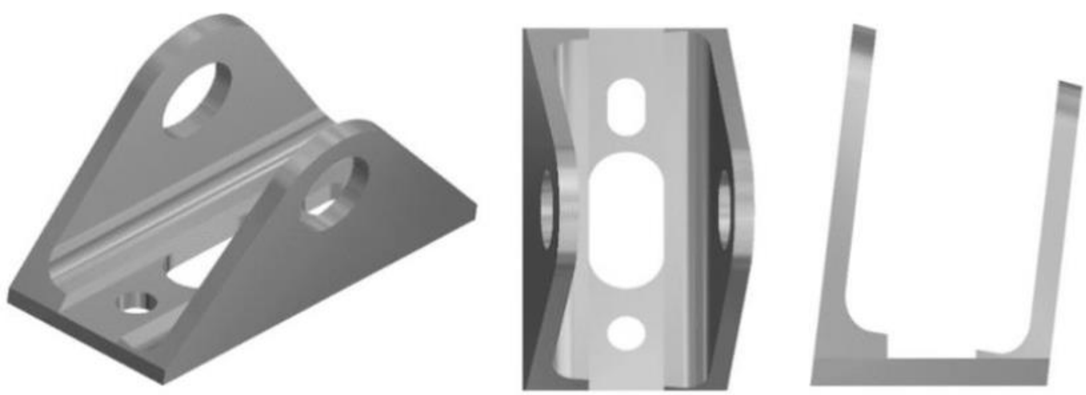
Also, clevis designers and the suspension lead should work closely with the monocoque subteam to confirm the positioning of bolt holes since there have been previous issues with the locations of mounting points. For ARG21, the front shock clevis had to be redesigned because the monocoque holes ended up being too close to the curved top section of the monocoque. As a result, the bolt holes had to be shifted on the clevis.

As the clevises are needed to be machined and mounted before the rest of the suspension assembly, it is very important that the clevises do not require second or third designs as this will delay the whole subteam.

For a more recent evolution of the suspension clevises, for ARG24, there was a big push to improve the standardization to help make manufacturing easier and to free up machine shop time for other more complex parts. ARG24’s clevis designer, Sam Zhen, introduced the SUCs (“somewhat universal clevises”) to replace many of the previously differing inboard clevises. [12]

ARG24 SUC-AN3 Clevis

In terms of the outboard clevises, for ARG20, the clevises were designed to be angled and mounted to a straight flange instead of mounting a straight clevis to an angled flange. While this reduced the number of post-machines needed to be done on an upright, it increased the complexity of clevis manufacturing, which is normally reserved for newly trained red-aprons and new members to gain manufacturing experience. For ARG24 these were made to be straight.



Angled outboard clevises from ARG20

3. Data (10)

The main design parameter driving the design of the clevises is the link load data since the clevises must withstand the loads transferred from the links.

Included below are the ARG25 link load cases, the main design parameter for the clevis designs:

Front (lbf)		Rear (lbf)	
FUF	422.8	RUF	356.8
FUR	550.7	RUR	531.7
FLF	1273	RLF	1069
FLR	1983	RLR	1014
STL	775.9	TOE	353.7
FPL	805.3	RPL	911.5
F_SHK	692.6	R_SHK	940.5
F_ARB	49.8	R_ARB	66.4

ARG25 Suspension Link Load Cases

These loads can be collected using the load cells on ARG24, and the max compression and tensile forces for each link can be found for the four main loading extremes: 1.2g of breaking, 2.0g of accel, 2.16g of corning, and 3.5g of bump. Whilst the validity of the suspension load cases is outside the scope of this report, I want to use this section of the report to discuss some future testing ideas that I would have liked to carry out on the clevises or that I hope can be carried out in the spring, time permitting.

Fatigue Test (Plan):

The suspension clevises experience cyclic forces applied to them, during their duration on the car and so are susceptible to fatigue. In Ben Ehemann's ARG23 Fall Technical report, he estimated that fatigue could reduce the tensile strength of Aluminum 7075 by up to two thirds. However, since the lifetime of a clevis and the low number of cycles that a clevis is likely to endure is relatively low, this type of testing has never been done on the suspension clevises. I do however think that it would be worthwhile testing a few clevises, especially the SUC clevises with an Instron at Bovey to see what the lifetime of a clevis is and how many cycles that it could withstand before failure.

Clevis Yield Test (Plan):

Again, using the Instron at Bovey, we could take some sacrificial clevises and verify the Air Force Model. The point of this test would be to see which failure mode would occur first and compare this with what we would expect from our model. Whilst so far this semester this has not been possible due to time constraints, I think it would be an important test to carry out early next semester. Otherwise, we may fall into the habit of carrying out analysis "because we did it last year". By testing the validity of our model, we could justify that using the AFM is the way forward for next year's part designer.

I think that the Clevis Yield test should take priority over fatigue testing so that we can have a clear path forward for next year's designs. I think that the relatively low number of cycles in a clevis' lifetime means that it is not strictly necessary to test for fatigue, but I think it would still be interesting to look into.

Margin of Safety and Safety Factors:

Since clevises are primarily designed to withstand the above-mentioned failure modes, it is very important for a clevis designer to understand Margin of Safeties, Safety Factors and Load Factors. Often margin of safeties are thought about in terms of: "Will my part break?" Instead, I would urge future clevis designers to think about them as a way of dictating what percentage you have exceeded your design criteria by, and therefore by what percentage your loads can increase in order to still meet your design criteria. For clevis design these should always stay positive.

Linear margins of safety can be calculated using the below formula:

$$MS = \frac{S * K}{SF * UF * \sigma} - 1$$

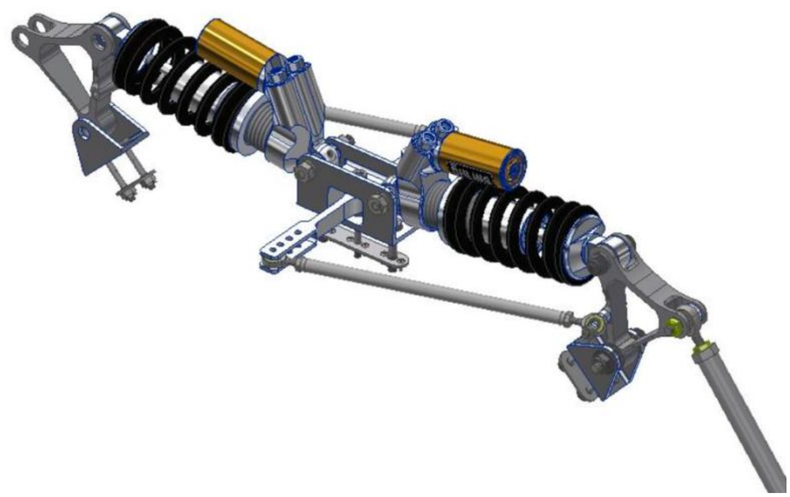
Where,

- S is the Applied Load
- K is the Knockdown Factor
- SF is the Safety Factor
- UF is the Uncertainty Factor
- σ is the Allowable Load

All Safety Factors, Knockdown Factors and Uncertainty Factors should be taken from the Cornell FSAE Confluence page [14], in line with team goals.

4. ARG25 Design(50)

This year the team has moved to an Anti-Roll Bar and Rocker Suspension system in response to the goal of designing a more tunable system to provide controllable and stable responses across different driving conditions. The introduction of these two new parts has meant that new clevises must be designed.



ARG25 Rocker and Anti-Roll

The ARG25 Clevis Assembly consists of 10 inboard clevises on each side of the car and a central shock/anti-roll bar clevis mounted to the front and rear of the car. Overall, this year there are 6 unique clevises down one from last year after another year of focusing on standardization. All together there are 22 inboard suspension clevises on ARG25. All Clevis Calculations can be found in the S;Drive (ARG25 Clevis Failure Mode Analysis). All Clevises are made up of Al-7075, the same as ARG24, due to the material's high strength-to-weight ratio and its ease of manufacturing.

ARG25 Suspension System

Inboard Clevis Naming

- Front clevises (F--):
  - Upper clevises (-U-):
    - FUF (Front Upper Front)
    - FUR (Front Upper Rear)
  - Lower clevises (-L):
    - FLF (Front Lower Front)
    - FLR (Front Lower Rear)
- Rear clevises (R--):
  - Upper clevises (-U-):
    - RUF (Rear Upper Front)
    - RUR (Rear Upper Rear)
  - Lower clevises (-L):
    - RLF (Rear Lower Front)
    - RLR (Rear Lower Rear)

SUC-AN3:

The SUC Clevises were introduced for ARG24 and designed with standardisation in mind. The clevises, although one of the simpler parts on the car, do take up a lot of manufacturing time due to the sheer quantity demanded. Whilst we could spend countless hours optimising each clevis and making each one unique, this makes manufacturing far more difficult and time consuming. The fewer variety of clevises we have, the quicker we can machine them and get them on the car ready for the rest of the suspension subteam.

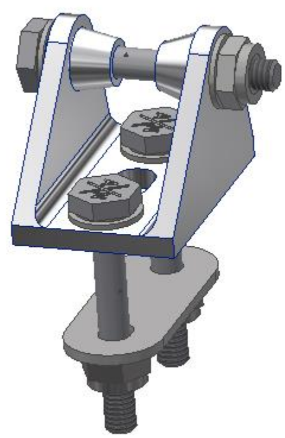
The main characteristics of a SUC-AN3 clevis are the standardized wall thickness of 0.125” and overall width of 1”. This width was determined by measuring the diameter of different tools to ensure that we could mount to the car with no issues. The main difference, compared to last year’s SUC AN3 was that the lug height increased to 0.750” in line with the suspension points this year being that distance from the surface of the monocoque.

The SUC-AN3 Clevises will be used on the FUF, FUR and the RLR due to similarities in load cases.

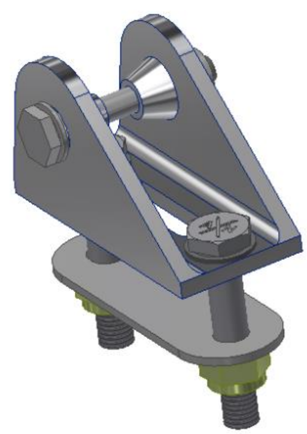
SUC-AN4:

Again, the SUC-AN4 Clevis is designed to improve the standardisation of the clevis assembly. With the same wall thickness and clevis width as the SUC-AN3, the height of the SUC-AN4 also increased to 0.75” in line with the points. The main difference between the AN3 and the AN4 is the edge distance (the difference between the centre of the clevis bore and the outer edge of the lug). This is determined by the higher link loads experienced at the rear area of the car and was calculated with the help of MechaniCalc’s Lug Calculator, when analysing lug strength for oblique loading.

The SUC-AN4 Clevises will be used for the FLF, FLR and the RLF again due to the similarities and higher link load cases in that area.



ARG25 SUC-AN3

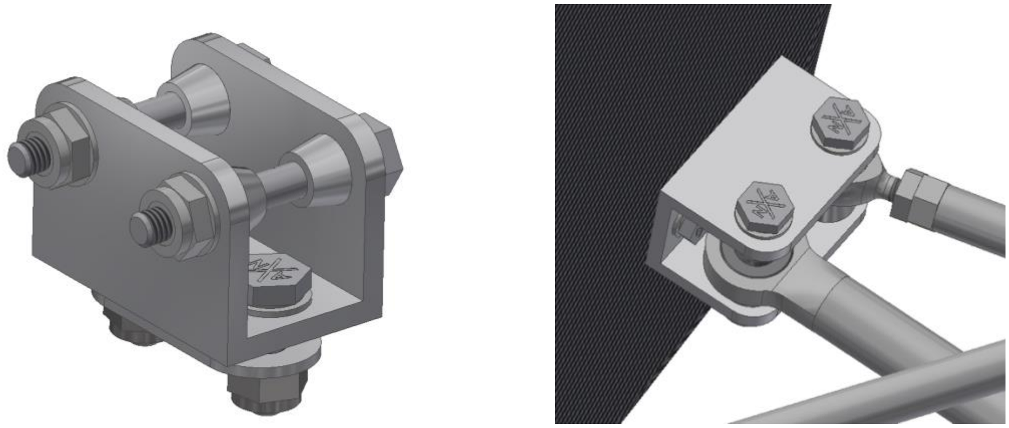


ARG25 SUC-AN4

RLR/Double Toe Clevis:

The RLR/Double Toe Clevis is not an entirely new clevis to ARG25’s system however the position of this double clevis has changed. Last year the clevis housing both the link and the toe link was on the upper rear section on the car, whereas this year it is located in the rear lower section. However ultimately the function of this clevis remains the same.

With the spherical bearings of the push link and toe link being different widths, the RLR clevis contains two different cones, each of different lengths to ensure that the



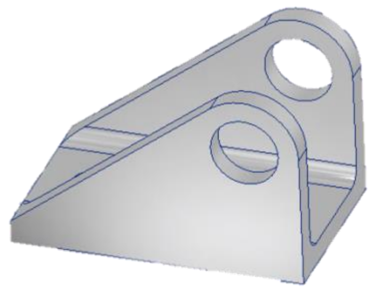
bearings are housed in the centre of the clevis pin and constrained to the suspension point. The forces that the toe link experiences are significantly lower than the forces transmitted through the RUR link, so in terms of analysis, it can still be modeled as a simple lug with the single RUR force being transmitted through it. However, both loads should be considered when analysing the bolt failure modes.

ARG25 RLR/Double Clevis

I would also urge any future clevis designer to double check the clearance between the spherical bearing edges and the mounting bolts for this and all other clevises.

RUR Clevis:

Initially the RUR Clevis was designed to be a SUC-AN3 along with the rest of the upper clevises. However, an issue that we found during the design cycle was that the mounting holes of the RUR was too close to the edge on the monocoque. We did not want to go closer than 0.75” to the edge of the monocoque and we did not want to change the suspension points again at such a late stage. Therefore, the RUR was designed to be an “offset” clevis. This means that the mounting holes for the clevis are not at the center of the base. This allowed the mounting bolts to be positioned further away from the edge of the monocoque whilst allowing the suspension point to remain in place.

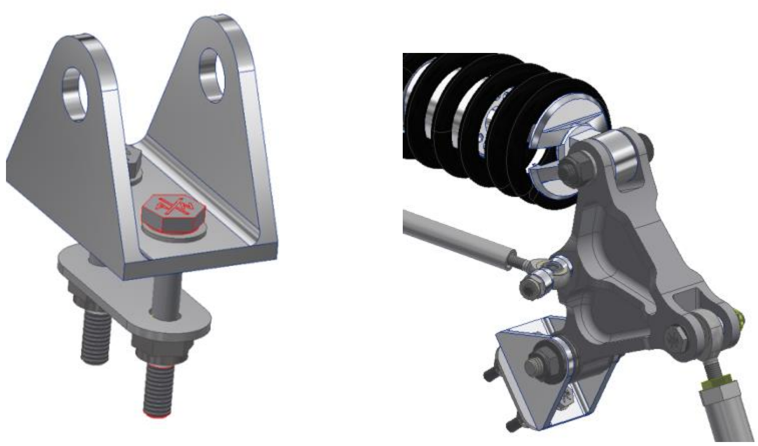


ARG25 RUR Clevis

Rocker Clevis:

The rocker clevis is the first of our new clevises this year and it is designed to house the rocker and its associated stack up. The width of this clevis was primarily determined by the width of the rocker and analyzed similarly to the rest of the inboard clevises.

However, I had to take greater care in resolving the loads since there were loads coming from the shock, the push link and the Anti-Roll Bar link. I would advise any future part designer to use the CAD in order to verify these components and really take care with resolving and check to make sure the values are realistic.



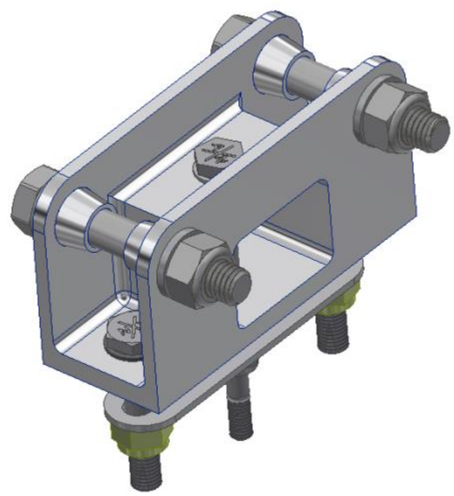
ARG25 Rocker Clevis and Integration

The height of the clevis bore was determined by the position of the suspension points above the monocoque, and the edge radius was determined using MechaniCalc's Lug Calculator, when analysing lug strength for oblique loading.

Shock Clevis:

The Shock/Anti-Roll Bar Clevis was the biggest addition to the suspension clevises this year. This clevis was designed to house the shocks and the antiroll bar and is mounted to the rear and front centre of the car.

It consists of two bolts through the clevis lugs to act as clevis pins for the shocks, a central bolt down that goes through the monocoque surface to mount the clevis and to act as a pin for the Anti-Roll Bar and two other AN4 bolts either side for additional mounting.

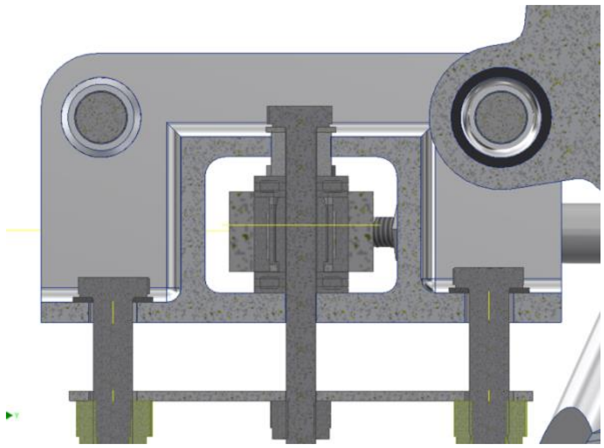


ARG25 Shock Clevis

Also in the assembly are 4 cones. Usually for a clevis stack up we will have one hat cone and one thru cone however the nature of the hat cone means that the angle of the cone must be much shallower so that the edge of the cone can sit flush to the lug wall. This shallower angle means that there will be some interference between the wider cone and the shock bearing. Therefore, we decided on having only thru cones.

One of the key considerations I had to make for the design of this clevis was the overall width. Originally, I designed the width narrow enough so that we could easily get a tool into the bolts similar to the way the SUCs were designed. However, after adding these clevises to the suspension master, we soon noticed interference between the edge of the lug and the shocks. After analysing the lug using MechaniCalc, we were able to reduce the lug edge which helped significantly with the interference, but we still had to make the clevis wider to provide adequate clearance for the shock.

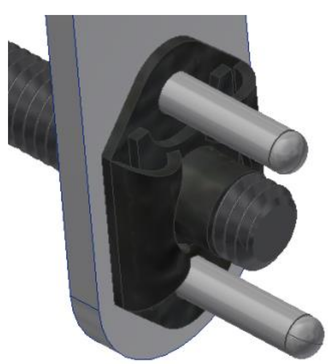
Another issue we had was the integration of the anti-roll bar. After analysing the centre bolt in double shear for the antiroll bar, I selected the pin and we tried to put the bar in, constrained to the suspension points. Our initial assembly had a cylindrical cone at the top and bottom of the central gap but with the height of the bearing proving to be taller than we had anticipated we found we only needed the top cone. After ADR the lengths of all the bolts were shortened to reduce some weight.



Cross Section of ARG25 Shock Clevis and Integration

The final issue raised just before ADR was how we were going to mount the shock clevis. As mentioned earlier in this report, clevises should abide by the philosophy of "Mount and Forget", however with the case of the antiroll bar, we discussed the need to remove and maybe replace the flexure and so the pin holding it in place would need to be accessible. The front of the car was not so much of an issue, but the rear would prove challenging to get access to with a tool due to the position of the inverter. So, we chose to use nut plates and rivets on the back of the shock backing plate so that we would not need to access the bolt from the back.

This design was inspired by the ARG24 drivetrain clevis backing plates and meant that divets had to be added to the shock backing plate to restrict rotation about the bolt's axis.



The analysis of the failure modes discussed earlier in this report and the calculations previously outlined are recorded in an excel spreadsheet to find the margin of safeties for each mode. All margin of safeties were positive for all modes and this spreadsheet can be found in the S:Drive.

If I had more time this semester, I would love to have learnt and ran FEA on all of the clevises, especially the newer clevises for this year. Unfortunately, this year, with a new monocoque to integrate to and a new suspension system to design, the link loads and suspension points continued to change pretty late into the design cycle and so I did not have time to learn and run FEA.

The constant changes to my design inputs were a challenge this semester, however I did implement CAD parametrization to make the design of so many parts much easier and quicker. I could input dimensions into an excel sheet and my designs would update with those changes. I would advise any future clevis designer or any other designer where their design parameters change regularly to look into parametrizing their CAD as it makes the process of adapting much quicker. It is really important however that you learn how to hand CAD a clevis so that you could troubleshoot your CAD if needed. Clevises are generally very beginner friendly parts to get started with CAD and are often used as an example for CAD training.

As mentioned before, if I had more time, I would also like to do some physical clevis testing. If someone were to test their designs, they would need to have some sacrificial clevis designed and manufactured very early in the design cycle which would be a challenge. I would recommend taking the previous year's clevis design and using that to verify the AFM model using the Intron at Bovey.

Weight Analysis:
Finally, I wanted to add the weight analysis of this years clevis assembly and compare with last years.

ARG24 Mass (lbmass)	ARG25 Mass (lbmass)
3.673	**3.794**

ARG24 vs ARG25 Weight Analysis

Whilst this year did see an increase in overall mass of the clevis assembly it is important to acknowledge that the ARG24 clevis assembly was made up of 20 inboard clevises, whereas ARG25 required 22 clevises.

5. Components Overview

Stock Ordered					
Material	**Purpose**	**Vendor**	**Price ($)**	**Quantity**	**Tensile Yield Strength**
1.5" x 2.5"Aluminum Rectangle Bar 7075-T7351- Cold Finish, 4' LONG	Clevis Stock	OnlineMetals	440.84	1	63,100 psi
90465K73, High-Strength 7075 Aluminum Rod, 1/2" Diameter, 2 ft. long	Cone Stock	McMaster-Carr	22.64	1	73,000 psi
Steel 1018, 0.0635" sheet	Backing plates	Clark	N/A	1	53,700 psi

Hardware Needed			
Item	**Purpose**	**Quantity**	**Vendor**
AN3-13 Bolt	Clevis Pins and Mounting	40	McMaster-Carr
AN4-14 Bolt	Mounting	12	McMaster-Carr
NAS6603-16	AN4 Clevis Pins	6	McMaster-Carr
91310A546_High-Strength Class 10.9 Steel Hex Head Screw	Shock Clevis Pin	4	McMaster-Carr
AN3-24 Bolt	ARB Bolt	2	McMaster-Carr
AN4-13 Bolt	Clevis Pins and Mounting	8	McMaster-Carr
AN3 Washer LoPro	Washers for clevis pin	66	McMaster-Carr
AN3 LockNut LoPro	Nut for interface bolts	18	McMaster-Carr
AN3 LockNut HiPro	Nut for interface bolts	28	McMaster-Carr

AN4 LockNut HiPro	Nut for interface bolts	12	McMaster-Carr
AN4 Washer LoPro	Washers for clevis pin	24	McMaster-Carr
M8 Standard washer	Shock Washer	8	McMaster-Carr
90576A117_Medium-Strength Steel Nylon-Insert Locknut	Nut for Shock Clevis	4	McMaster-Carr
97519A003 Rivets	Shock Backing Plate Rivets	12	McMaster-Carr
90857A134 (AN3 Nutplate)	Shock Backing Plate Nutplates	2	McMaster-Carr
90857A135 (AN4 Nutplate)	Shock Backing Plate Nutplates	4	McMaster-Carr
AN4 Locknut LoPro	Washers for clevis pin	4	McMaster-Carr

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