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RESEARCH ARTICLE OPEN ACCESS

# Dynamic Analysis of Double Wishbone and Double Wishbone with S Link + Toe Link

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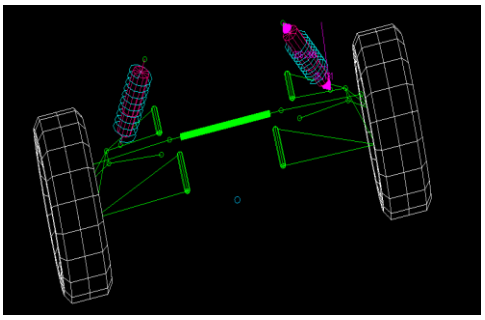
**ABSTRACT:**
Double wishbone or A arm are solid links used to connect the vehicles chassisto its wheels . These links provide better ride to the customers but in conditions of bumps and rebounds toe change increases drastically.This paper studies about the model of double wishbone used in off-road racing cars. Dynamic analysis of Wishbones is done in '**LOTUS-Shark V 5.01'**. Analysis is also done by changing the design of double wishbone. By applying an extra link named toe link and S link for providing two mounting points.
**Keywords:** s-link, toe-link

## I. Introduction



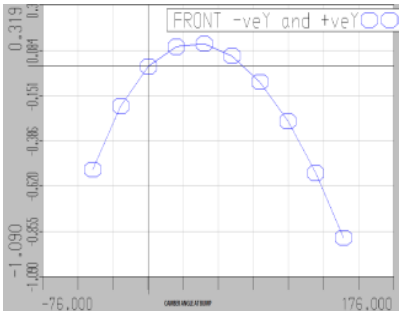
Double wishbone is a type of suspension system which connects frame to tyres and also provides best handling Performance for the driver comfort we just introduce an extra link named "**Toe Link**" with that upper wishbone so toe changes minimum in the condition of bump steer , means when vehicle passes over a bump there is a condition of instability where toe changes instantly. By providing this toe link change in toe angle is nearly zero.

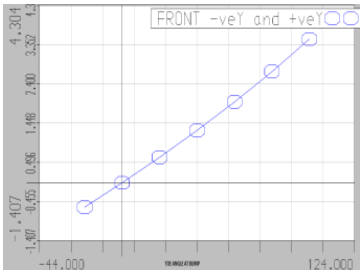
**S-Link** provides a connection between the upright and wishbone. It has two ports in frame direction and single towards tire side. With the help of ball joints, toe link and wishbone is connected to S-link on one side and a simple knuckle joint is wishbone. This link simply connects the upper wishbone to lower wishbone to restrict two plane motion of the upper wishbone. If it is not so then our vehicle can't be able to take turn. By providing this link, upper wishbone can move up and down only but toe link has two plane motion.provided between S-link and upright. Hence, there is only one plane motion between S-link and upright to steer our vehicle.
Another link is also provided between upper and lower

## II. Analysis of conventional or simple double wishbone

For the support of concept we have provided results of "**LOTUS-SHARK V 5.01**".
By taking same amount of the bump and rebound conditions results are plotted.
For conventional double wishbone toe change can be noticed from graphs and results.

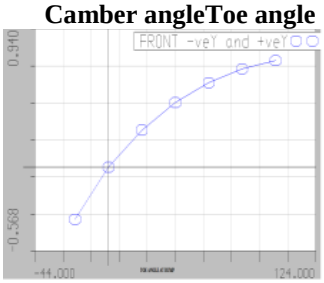
**Graphs of Double Wishbone**



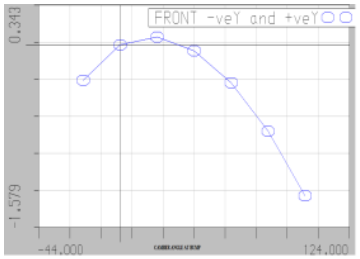



**Camber change Toe change**

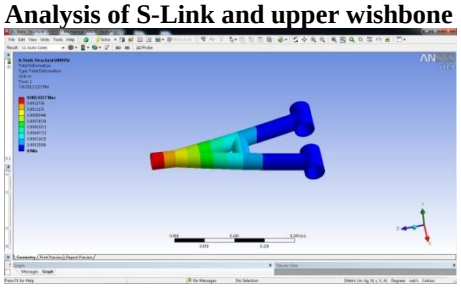
**Camber angleToe angle**

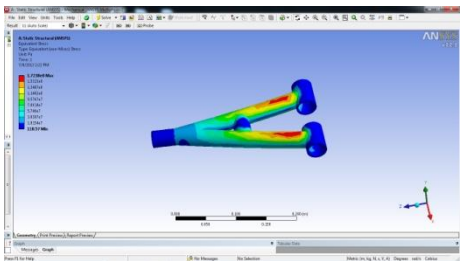



Analysis of Double wishbone with toe link + S- Link



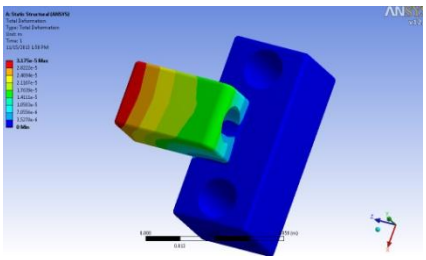

**Analysis of S-Link and upper wishbone**

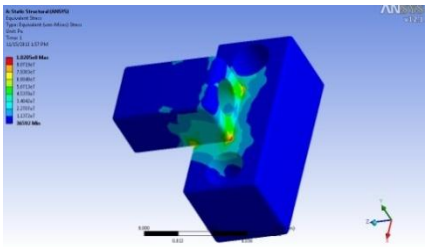




Deformation Stress concentration
Fos :- 2.96

DeformationStress concentration
Fos:- 4.52





Front Suspension Filename: Final For Front Production.Shk

## III. Lotus results for wishbone

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## IV. Lotus Suspension Analysis V5.01

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TYPE 18 Double Wishbone, Upper toe link + S link

STATIC VALUES

| X (mm) | Y (mm) | Z (mm) | | |
|---|---|---|---|---|
| 3950.00 | -180.00 | 280.00 | POINT:1 | Lower wishbone front pivot |
| 4100.00 | -180.00 | 280.00 | POINT:2 | Lower wishbone rear pivot |
| 4000.00 | -530.00 | 204.00 | POINT:3 | Lower wishbone outer ball joint |
| 4000.00 | -250.00 | 530.00 | POINT:4 | Upper wishbone front pivot |
| 4100.00 | -250.00 | 530.00 | POINT:5 | Upper wishbone rear pivot |
| 4025.00 | -450.00 | 480.00 | POINT:6 | Upper wishbone outer ball joint |
| 4035.22 | -395.05 | 478.06 | POINT:7 | Damper wishbone end |
| 4096.70 | -259.67 | 780.47 | POINT:8 | Damper body end |

4130.00 -510.00 300.00 POINT:9 Outer track rod ball joint
4100.00 -210.00 360.00 POINT:10 Inner track rod ball joint
4000.00 -550.00 292.00 POINT:13 Wheel spindle point
4000.00 -600.00 292.00 POINT:14 Wheel centre point
3900.00 -260.00 550.00 POINT:15 Upper toe link inboard end
3975.00 -450.00 480.00 POINT:16 Upper toe link outboard end
4000.00 -530.00 380.00 POINT:17 Drop link axis point
4030.00 -440.00 190.00 POINT:18 Part 1 C of G
4170.00 -480.00 450.00 POINT:19 Part 2 C of G
4230.00 -525.00 220.00 POINT:20 Part 3 C of G
4070.00 -630.00 440.00 POINT:21 Part 4 C of G
4020.00 -510.00 455.00 POINT:22 Part 5 C of G
4130.00 -725.00 260.00 POINT:23 Part 6 C of G
3950.00 180.00 280.00 POINT:201 Lower wishbone front pivot(2)
4100.00 180.00 280.00 POINT:202 Lower wishbone rear pivot(2)
4000.00 530.00 204.00 POINT:203 Lower wishbone outer ball joint(2)
4000.00 250.00 530.00 POINT:204 Upper wishbone front pivot(2)
4100.00 250.00 530.00 POINT:205 Upper wishbone rear pivot(2)
4025.00 450.00 480.00 POINT:206 Upper wishbone outer ball joint(2)
4035.22 395.05 478.06 POINT:207 Damper wishbone end(2)
4096.70 259.67 780.47 POINT:208 Damper body end(2)
4130.00 510.00 300.00 POINT:209 Outer track rod ball joint(2)
4100.00 210.00 360.00 POINT:210 Inner track rod ball joint(2)
4000.00 550.00 292.00 POINT:211 Wheel spindle point(2)
4000.00 600.00 292.00 POINT:212 Wheel centre point(2)
3900.00 260.00 550.00 POINT:213 Upper toe link inboard end(2)
3975.00 450.00 480.00 POINT:214 Upper toe link outboard end(2)
4000.00 530.00 380.00 POINT:215 Drop link axis point(2)
4030.00 440.00 190.00 POINT:216 Part 1 C of G(2)
4170.00 480.00 450.00 POINT:217 Part 2 C of G(2)
4230.00 525.00 220.00 POINT:218 Part 3 C of G(2)
4070.00 630.00 440.00 POINT:219 Part 4 C of G(2)
4020.00 510.00 455.00 POINT:220 Part 5 C of G(2)
4130.00 725.00 260.00 POINT:221 Part 6 C of G(2)

STATIC VALUES
Camber Angle (deg): 0.00
Toe Angle {Plane} (deg): 0.00
Toe Angle {SAE} (deg): 0.00
Castor Angle (deg): 0.00
Castor Trail (hub) (mm): 0.00
Castor Offset (grnd) (mm): 0.00
Kingpin Angle (deg): 0.00
Kingpin Offset (w/c) (mm): 70.00
Kingpin Offset (grnd) (mm): 70.00
Mechanical Trail (grnd) (mm): 0.00
ROLL CENTRE HEIGHT (mm): 112.96

GENERAL DATA VALUES
TYRE ROLLING RADIUS (mm): 292.00
WHEELBASE (mm): 1550.00
C OF G HEIGHT (mm): 510.00
BREAKING ON FRONT AXLE (%): 60.00
DRIVE ON FRONT AXLE (%): 0.00
WEIGHT ON FRONT AXLE (%): 40.00
OUTBOARD FRONT BRAKES:
OUTBOARD REAR BRAKES:
INDEPENDENT FRONT SUSPENSION:
INDEPENDENT REAR SUSPENSION:
RACK TYPE STEERING ARTICULATION:

RUN DETAILS
FULL MODEL:
BUMP TRAVEL (mm): 100.00 INCREMENT (mm): 20.00
REBOUND TRAVEL (mm): 20.00 INCREMENT (mm): 20.00
ROLL ANGLE (deg): 3.00 ROLL INCREMENT (deg): 0.50
STEERING TRAVEL (mm): 50.00 STEERING INCREMENT (mm): 5.00

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LOTUS SUSPENSION ANALYSIS v5.01

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FRONT SUSPENSION - BUMP TRAVEL

LHS WHEEL (-ve Y)

TYPE 18 Double Wishbone, Upper toe link + S link

INCREMENTAL GEOMETRY VALUES

| Bump Travel (mm) | Camber Angle (deg) | Toe Angle {SAE} (deg) | Castor Angle (deg) | Kingpin Angle (deg) | Damper1 Ratio (-) | Spring1 Ratio (-) |
|---|---|---|---|---|---|---|
| 100.00 | -1.3045 | 0.7244 | 0.2104 | 1.3072 | 1.230 | 1.230 |
| 80.00 | -0.7469 | 0.6674 | 0.1938 | 0.7492 | 1.240 | 1.240 |
| 60.00 | -0.3263 | 0.5738 | 0.1666 | 0.3280 | 1.246 | 1.246 |
| 40.00 | -0.0497 | 0.4388 | 0.1273 | 0.0506 | 1.248 | 1.248 |
| 20.00 | 0.0683 | 0.2532 | 0.0734 | -0.0680 | 1.242 | 1.242 |
| 0.00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.225 | 1.225 |
| -20.00 | -0.3048 | -0.3530 | -0.1022 | 0.3054 | 1.205 | 1.205 |

## V. Incremental Suspension Parameter Values

| Bump Travel (mm) | Anti Dive (%) | Anti Squat (%) | Roll Centre Height {to Body} (mm) | Roll Centre Height {to Grnd} (mm) | Half Track Change (mm) | Wheelbase Change (mm) | Damper1 Travel (mm) | Spring1 Travel (mm) |
|---|---|---|---|---|---|---|---|---|
| 100.00 | -0.08 | 0.00 | 130.86 | 30.86 | 12.07 | -1.29 | -80.57 | -80.57 |
| 80.00 | -0.15 | 0.00 | 127.89 | 47.89 | 10.79 | -1.16 | -64.38 | -64.38 |
| 60.00 | -0.22 | 0.00 | 125.16 | 65.16 | 8.94 | -0.97 | -48.29 | -48.29 |
| 40.00 | -0.29 | 0.00 | 122.23 | 82.23 | 6.51 | -0.73 | -32.26 | -32.26 |
| 20.00 | -0.39 | 0.00 | 118.50 | 98.50 | 3.52 | -0.42 | -16.20 | -16.20 |
| 0.00 | -0.51 | 0.00 | 112.96 | 112.96 | 0.00 | 0.00 | 0.00 | 0.00 |
| -20.00 | -0.71 | 0.00 | 103.72 | 123.72 | -3.97 | 0.60 | 16.47 | 16.47 |

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LOTUS SUSPENSION ANALYSIS v5.01

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FRONT SUSPENSION - BUMP TRAVEL

RHS WHEEL (+ve Y)

TYPE 18 Double Wishbone, Upper toe link + S link

INCREMENTAL GEOMETRY VALUES

| Bump Travel (mm) | Camber Angle (deg) | Toe Angle {SAE} (deg) | Castor Angle (deg) | Kingpin Angle (deg) | Damper1 Ratio (-) | Spring1 Ratio (-) |
|---|---|---|---|---|---|---|
| 100.00 | -1.3045 | 0.7244 | 0.2104 | 1.3072 | 1.230 | 1.230 |
| 80.00 | -0.7469 | 0.6674 | 0.1938 | 0.7492 | 1.240 | 1.240 |
| 60.00 | -0.3263 | 0.5738 | 0.1666 | 0.3280 | 1.246 | 1.246 |
| 40.00 | -0.0497 | 0.4388 | 0.1273 | 0.0506 | 1.248 | 1.248 |
| 20.00 | 0.0683 | 0.2532 | 0.0734 | -0.0680 | 1.242 | 1.242 |
| 0.00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.225 | 1.225 |
| -20.00 | -0.3048 | -0.3530 | -0.1022 | 0.3054 | 1.205 | 1.205 |

INCREMENTAL SUSPENSION PARAMETER VALUES

Bump Travel (mm) | Anti Dive (%) | Anti Squat (%) | Roll Centre Height {to Body} (mm) | Roll Centre Height {to Grnd} (mm) | Half Track Change (mm) | Wheelbase Change (mm) | Damper1 Travel (mm) | Spring1 Travel (mm)

100.00 -0.08 0.00 130.86 30.86 12.07 -1.29 -80.57 -80.57
80.00 -0.15 0.00 127.89 47.89 10.79 -1.16 -64.38 -64.38
60.00 -0.22 0.00 125.16 65.16 8.94 -0.97 -48.29 -48.29
40.00 -0.29 0.00 122.23 82.23 6.51 -0.73 -32.26 -32.26
20.00 -0.39 0.00 118.50 98.50 3.52 -0.42 -16.20 -16.20
0.00 -0.51 0.00 112.96 112.96 0.00 0.00 0.00 0.00
-20.00 -0.71 0.00 103.72 123.72 -3.97 0.60 16.47 16.47

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## VI. Conclusion

It is clear from the graphs there is a small or negligible change in the toe angle when vehicle faces the condition of bump and rebound. Moreover, the height of the rack mounting is also low with double wishbone +slink +toe link. Therefore in condition of simple Ackermann if rack is placed behind the pedals (especially in off-road vehicles) Comfort ability increases to large extend for driver because pedals can be operated without facing any obstacles.

## References

[1] LOTUS SHARK V-5.01
[2] Anonymous (1992) Directive 92/7/EC, (on definition and testing of 'road friendly suspension'), Council of the European communities.
[3] Bastow D.(1980) car suspension and handling, 1st edn., Pentech press