SUSPENSION GEOMETRY ANALYSIS OF FORMULA VARSITY RACE CAR

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I certify that this thesis is really my own work accept the statement and the article that each one I have state their resources.

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Date : ....13 MEI 2008.......................................

DEDICATION

To my beloved mother and father

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ABSTRACT

A *wheel plane* and *durability* simulation has been performed in order to develop a suspension system. It was determined that to better design of the suspension, the simulation have to be as close the reality as possible. In suspension design the most importance thing is to get the suspension geometry. The design of the suspension will be doing by using a coding using notepad. By import those files the simulation of the suspension will be perform by ADAMS/View.

ABSTRAK

Simulasi '*wheel plane*' dan '*durability*' telah dijalankan bertujuan untuk membina sistem suspensi. Telah dikenal pasti bahawa untuk mendapatkan rekaan sesuatu suspensi yang baik, simulasi haruslah menyerupai realiti. Didalam rekaan suspensi perkara yang paling penting ialah untuk mendapatkan geometri suspensi. Rekaan suspensi itu akan dilakukan dengan menggunakan kod dengan menggunakan notepad. Dengan mengimport fail notepad itu simulasi suspensi akan dibuat dengan menggunakan ADAMS/VIEW.

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CHAPTER I

INTRODUCTION

Designing suspension systems for production or racing car requires technical knowledge in several disciplines. This thesis will cover one of those disciplines. It is the study of suspension geometry.

When we talk about suspension geometry in mean the broad subject of how the unsprung mass of a vehicle is connected to the sprung mass. These connections not only dictate the path of relative motion, they also control the forces that are transmitted between them.

Any particular geometry must be designed to meet the needs of the formula varcity race car for which it is to be applied.

1.1 PROBLEM STATEMENT

The problem is how to choose the greatest suspension geometry design. Based on the design given, compare the design with other variation of double wishbone suspension system. The design will be compare with analysis using Adam/view.

1.2 PROJECT BACKGROUND

With today computer software and hardware it might seem quite simple to model and simulate a full vehicle in the computer. This project is about to design the geometry and analysis the suspension system for the formula varsity race car. The design of formula varsity race car is in SolidWorks 2007.

1.3 SCOPE

1. To do analysis of suspension system using MSC. Adams/view 2007 r1.
2. Study on how to do analysis using MSC. Adams/view 2007 r1.
3. Literatures review on suspension behavior.
4. Doing programming for MSC. Adams

1.4 OBJECTIVE

1. To determine suspension geometry analysis for a formula varsity race car.

CHAPTER II

LITERATURE REVIEW

2.0 FSAE suspension

FSAE suspensions operate in A narrow realm of vehicle dynamics mainly due to the limited cornering speeds which are governed by the racetrack size. Therefore, FSAE suspension design should focus on the constraint of the competition. The vehicle track width and wheelbase are factors governing the success of the car handling characteristic. These two dimensions not only influence weight transfer, but they also affect the turning radius. In order to achieve high performance, the acceleration of the car must be maximized. The parameter that governs the acceleration of the car is the tractive force between the tires and the roadway. Therefore in order to maximize the acceleration of the car, traction must be maximized.

Basic part of FSAE suspensions:

A arm

The arm is designed to maximum control to the wheel travel of the car during motion from steering for impact. The unequal nature of the A arm is implemented to have desirable camber adjustment during steering and are arranged to maintain a roll center near the bottom of the chassis.

Push rod

The push rod idea is used so that the resulting forces inputs on the chassis, rocker arm are primary loaded in compression while the pull rod in tension. The orientation of the system is coil over so that the two components behave linear in relation to each other.

Pull rod

The pull rod, A-arms and tie rods will be constructed from 1018 carbon steel in order to reduce cost, provide the necessary strength and eliminate the need for post weld treatment as would be seen in more exotic metals.

Rocker arm

The rocker arm is designed and placed in order to translate the pull rod and push rod motion to the longitudinal shock as well as effectively providing a rising motion profile for the spring travel.

Upright

The machined one piece aluminium upright are designed to provide maximum strength for minimum weight. The upright is home to a single bearing hub which the axle a ride.

2.1 Degrees of freedom and motion path

For any body moving in space relative to another body, its motion can be completely define by three component of linear motion and three components of rotational motion. A single body is said to have six degree of freedom of motion in a three dimensional world. (William and Douglas 1995) said above that any independent suspension allows only one path of motion of the knuckle relative to the body. Another way to say the same thing is that the suspension provides five degree of restraint it severely limits motion in five directions. In the real world, the mechanical components that supply the restraint are not perfect in the sense of restraining the motion to a particular degree of freedom. Therefore the study of independent suspension geometry is to determine how to restrain the knuckle to limited motion in five directions.

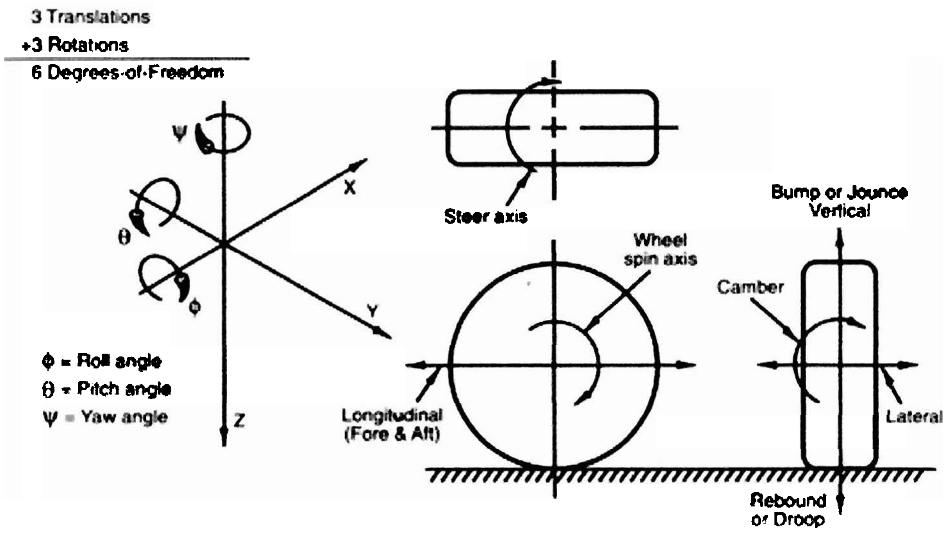

Figure 2.1 Degree of freedom and suspension motion definitions.

If the only components that can use to design suspension geometry were straight links with rod end (spherical joint) on each end, require restrains can be provide with five of them. In other word to obtain five degree of restraint requires exactly five tension compression links. To relate this concept to Adams/view, (William and Douglas 1995) need to understand how typical suspension component provide their restraining function. The standard racing double wishbone suspension has two A-arm plus a tie rod. Thus two link for each A-arm and one link for the tie rod adds up to five.

2.2 Instant center define

The term instant center will be used in describing and determining several common suspension parameters. The word instant means at that particular position of the linkage. Center refers to a projected imaginary point that is effectively the pivot point of the linkage at that instant. (William and Douglas 1995) proper geometry design not only establishes all the instant centers in their desired positions at ride height, but also controls how fast and in what direction they move with the suspension travel.

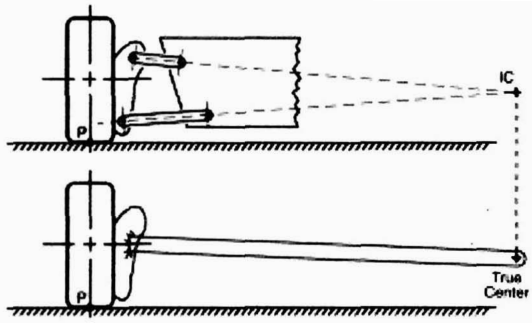

Figure 2.2 Instant center concept.

Instant center come from the study of kinematics in two dimensions. They are convenient graphic aid in establishing motion relationship between two bodies. In suspension design it is convenient to break down this three dimensional problem into two, two dimensional problems.

2.3 Instant axis

In true three-dimensional space, instant centers are replaced by instant axes. When the instant center defined in side view and front view are connect together, one line will produce. (William and Douglas 1995) this line can be thought as the instant axis of motion of the knuckle relative to the body.

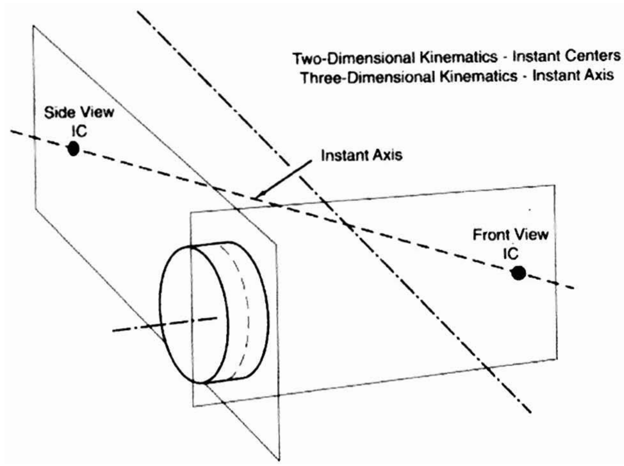

Figure 2.3 Instant axis concept.

Independent suspension has one instant axis of motion because they have five restraints.

2.4 Independent suspension

For all independent suspension (William and Douglas 1995) said there are the two instant centers which change with bump and droop that establish the properties of that particular design. The side view instant center control force and motion factors predominantly related to fore and aft acceleration, while the front view instant or swing center control force and motion factors due to lateral acceleration.

2.5 Front view swing arm geometry

The front view swing arm instant center location controls the roll center height, the camber change rate and tire lateral scrub. The instant center can be located inboard of the wheel or outboard of the wheel. It can be above ground level or below ground.

2.6 Roll center height

The roll center height is found by projecting a line from the center of the tire ground contact path through the front view instant center as showing in Figure 2.4(a). This is repeated for each side of the car. Where these two lines intersect is the roll center of the sprung mass of the car, relative to the ground. It is not necessarily at the centerline of the car especially with asymmetric suspension geometry Figure 2.4(b) or once the car assumes a roll angle in a turn. (William and Douglas 1995) it is obvious that the roll center location is control by the instant center heights above or below ground, the distance away from the tire that the instant center is placed, and whether the instant center is inboard or outboard of the tire contact path.

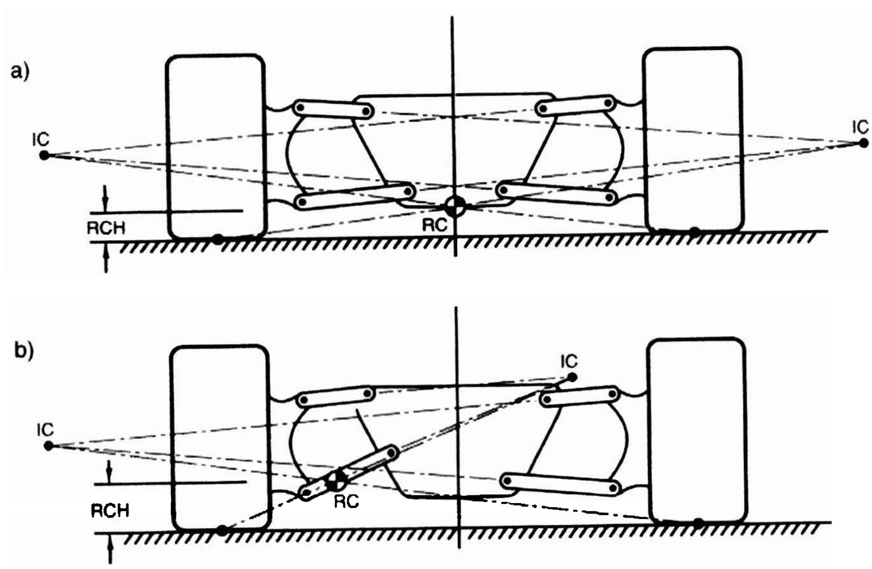

Figure 2.4 Roll center construction

The roll center establishes the force coupling point between the unsprung and sprung masses. When a car corners, the centrifugal force at the center of the gravity is reacted by the tires. The lateral force at the center gravity can be translated to the roll center if the appropriate force and moment about the roll center are shown. The higher the roll centers the smaller the rolling moment about the roll center, the lower the roll center the larger the rolling moment. (William and Douglas 1995) have notify that, with higher roll centers the lateral force acting at the roll center is higher off the ground. This lateral force multiply by the distance to the ground can be called the nonrolling overtuning moment. So roll center height are trading off the relative effects of the rolling and nonrolling moment.

Another factor to establish the desired roll center height is horizontal-vertical coupling effect. If the roll center is above ground level the lateral force from the tire generates a moments about the instant center. This moment push the wheel down and lift the sprung mass and it is called jacking. If the roll center is below the ground level then the force will push the sprung mass down. In either case the sprung mass will have a vertical deflection due to a lateral force. Here the total force at the contact patch is drawn to its reaction point at the instant center and the lateral and vertical components are indicated the vertical component in the case shown will lift the sprung mass.

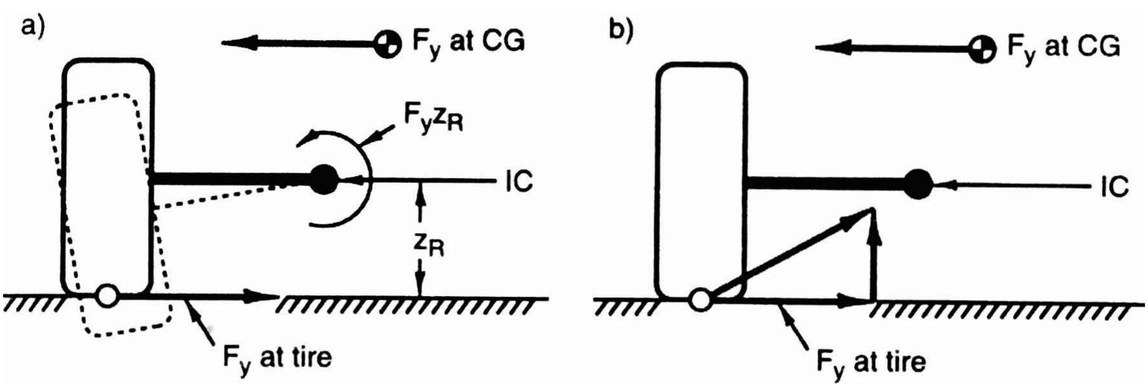

Figure 2.5 Jacking effect with a high roll center

2.7 Camber change rate

While the roll center is a function of a front view swing arm length and height, the camber change rate is only a function of front view suspension swing arm length.

2.8 Rate of change of front view swing arm

Instant centers move with wheel ride travel. How fast they move is a function of the absolute and relative lengths of the control arms in the front and side views. A camber curve can be made to have more or less camber change with wheel travel by altering the length of the upper control arm even though it is aimed at the same instant center at ride height.

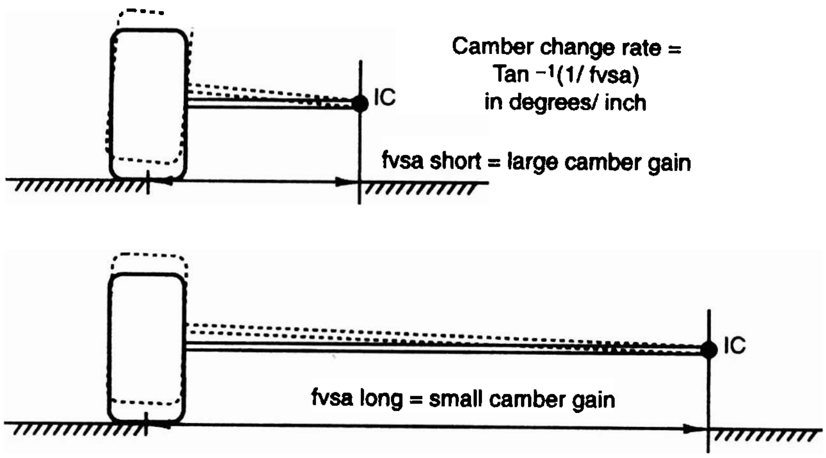

Figure 2.6 Camber change

2.9 Scrub

Another front view variable is tire scrub. This is the lateral motion to the ground that results from vertical motion of the wheels. Scrub occurs in every suspension system. The amount of scrub is a function of the absolute and relative length of the control arms and the position of the front view instant center relative to the ground. When the front view instant center is at any position other then ground level, scrub is increased. If it is above ground and inboard, the tire will move inward with jounce travel. The amount that it moves is a function of the swing arm length and the absolute height from ground.

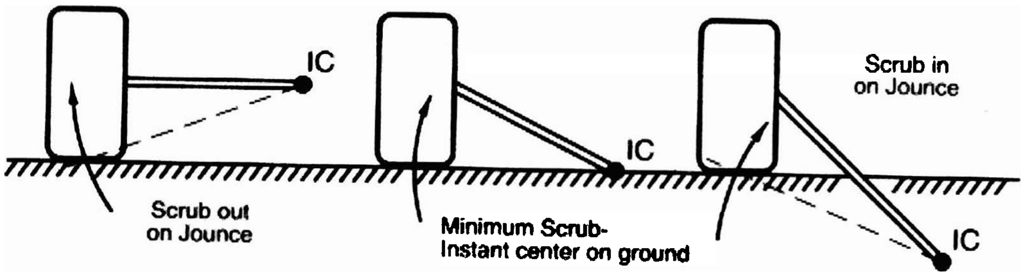

Figure 2.7 Scrub is a function of instant center height

On a rough road the wheel path is not a straight line if there is scrub. Significant amount of scrub introduce lateral velocity component at the tire which when added to the forward velocity, change the tire slip angle. This in turn will laterally disturb the car. The same slip angles will also add viscous damping to the ride motion.

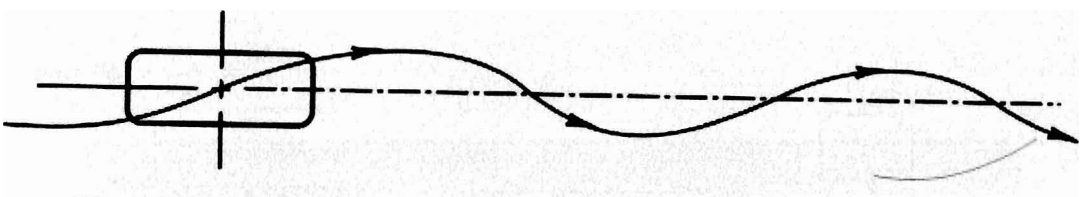

Figure 2.8 Wheel path on rough road with a large amount of scrub

2.10 Side view swing arm geometry

The side view swing arm control motions and forces in the fore and aft direction. Typical suspension parameters are anti-dive, anti-lift, anti-squat and wheel path. The position of the side view swing arm, ahead and above the wheel center, are all possible solutions for front and rear independent suspensions. Typically the instants center is behind above the wheel center on front suspension and it is ahead and above on most rear suspension.