Design of Air-Rover Undercarriage

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Abstract
Air-Rover is a design of an aircraft which can operate on rough runaways. This is to benefit mainly third world countries with easy operation on drift runaways such as grass or bare soil. Aircraft can carry 5000 kg of payload either cargo or passenger and total weight of 14000 kg.

When operating on rough fields it is obvious to experience lots of gusts on the aircraft which is sometimes unexpected. The landing gear which takes all the gusts during taxing on the airfield, take off the flight and landing should be designed in such a way that it would take all the bumps exercising by the body.

Normally when it comes to rough field the wavy pattern on the surface is more than a smooth surface where the aircraft tend to bump more. This is an unacceptable phenomenon in aeronautical engineering which could cause severe damages to the aircraft. So that the intention of this project to minimize the gusts taken by the main body.

Several design concepts have been achieved to overcome the situation such that choosing low pressure large wheels tyres enhance the stability of aircraft.
The shock absorber which plays a main role had been designed as double acting shock absorber which could intake a disturbance more efficiently.

The design had been kept simple, easy to repair stage with less maintainability cost as this is to benefit all third world countries. But still it's a fact to overcome the skidding of aircraft during rainy days.

Keywords: Air-Rover, Undercarriage, Drift runaways, Payload, Landing gear

Introduction
The concept is to use Western Aerospace Technology and Business Acumen plus International Aid Finance and Local Knowledge to provide an air-based Transport Infrastructure, able to operate in the vast country areas currently without adequate road / rail / river transport links.

The object is to use Aviation to 'open-up' these countries over the next few decades, allowing the inhabitants to move around more easily, but more importantly, enabling trade goods to move quickly and economically within, into and out of the area. The consequent expansion of trade will in time lead to the air transport system paying its way. It will eventually raise the economic level of the country sufficiently to enable the more economic (to operate) road and rail infrastructures to be built later in the century.

The working name AIR ROVER was given to suggest a class of aircraft able to 'go anywhere', especially to reach communities down to the village level.

The scale of the program could be about 50,000 aircraft over a period of 50 years, at an average cost of around 2million dollars. The operation and support of the world AIR ROVER fleets for 50 years would be an even larger activity. The potential value to BAES might perhaps 100 billion dollars.'

The main design feature of this air craft is to take off and land on rough surfaces and is capable of carrying a standard load. The cabin is large enough to carry ISO containers or 40 economy class seats for passengers. As this is in experimental stage it still contains economy class passenger seats and an unpressurized cabin as it flies at considerably low altitudes. The range of the flight is 10 000km in 10*100km segments.

The main design features go along with this design particularly for a cargo air rover is cargo access via swing tail at the back therefore kneeling down undercarriage and partially retractable. Considering these two main features the design of the undercarriage is tricycle type, single wheel and all three wheels are identical. This feature is kept for the simplicity and to benefit all third world countries.

COST ESTIMATION

Air craft purchase	$ 2,000,000
Maintenance over 15 years	$ 1,000,000
Fuel used over 15 years	$ 4,000,000
Air crew over 15 years	$ 1,000,000

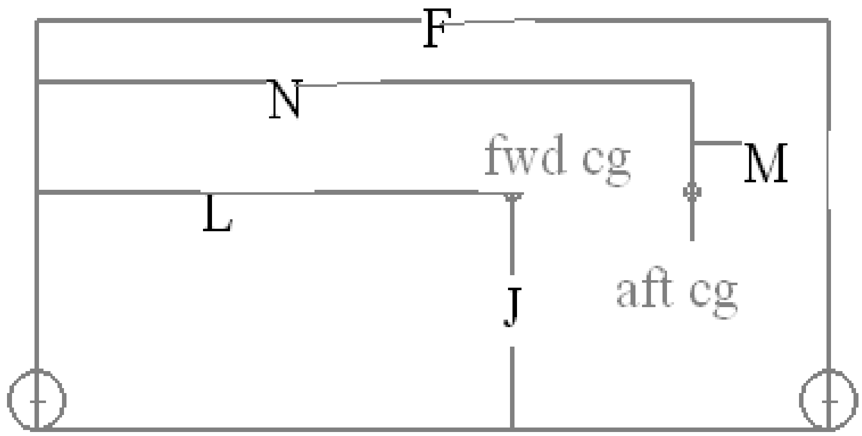
Total direct cost over 15 years	$ 8,000,000

In addition to above there will be some minor organizational overheads such as training, Navigation aids, Landing fees, Management, Insurance etc.

Objective

The objective of the design of an undercarriage which can operate on drift runaways is to benefit the end user like countries in Africa and all other third world countries. An undercarriage which can tolerate gusts giving smooth landing and take off facility.

Design
Initial Layout



Nose Gear **Main Gear**

Initial layout of undercarriage

The distance between the nose gear and the main gear is 6.75m F = 6.75m

The distance from nose gear to forward cg is 5.36m L = 5.36m

The distance from nose gear to aft cg is 6.16m N = 6.16m

The distance form aft cg to main gear is 0.59m M = 0.59m

The height from wheels to the centre of gravity is 2.4m J = 2.4m

Wheel selection

Tricycle gear type for ultimate stability.
Large single wheel tyres with 30 psi pressure.

Gear Loadings

Design concept

The data which was given in specifications;

The max nose gear load would be approximately 20% of total weight

Which is 14 000 * 20/100 = 2 800kg

The Min Nose gear load would be approximately 10% of total weight

Which is 14 000* 10/100 = 1400kg

<u>Calculated values</u>

Maximum static main gear load	= W (F-M) / 2F
	= 14000 (6.75-0.59) / 2*6.75
	= 6 388 kg
Maximum static nose gear load	= W (F-L) / F
	= 14000 (6.75-5.36) / 6.75
	= 2 883 kg
Minimum static nose gear load	= W (F-N) / F
	= 14000 (6.75-6.16) / 6.75
	= 1 223 kg

- According to calculated values it shows there's no big difference in between the design concept and calculations.

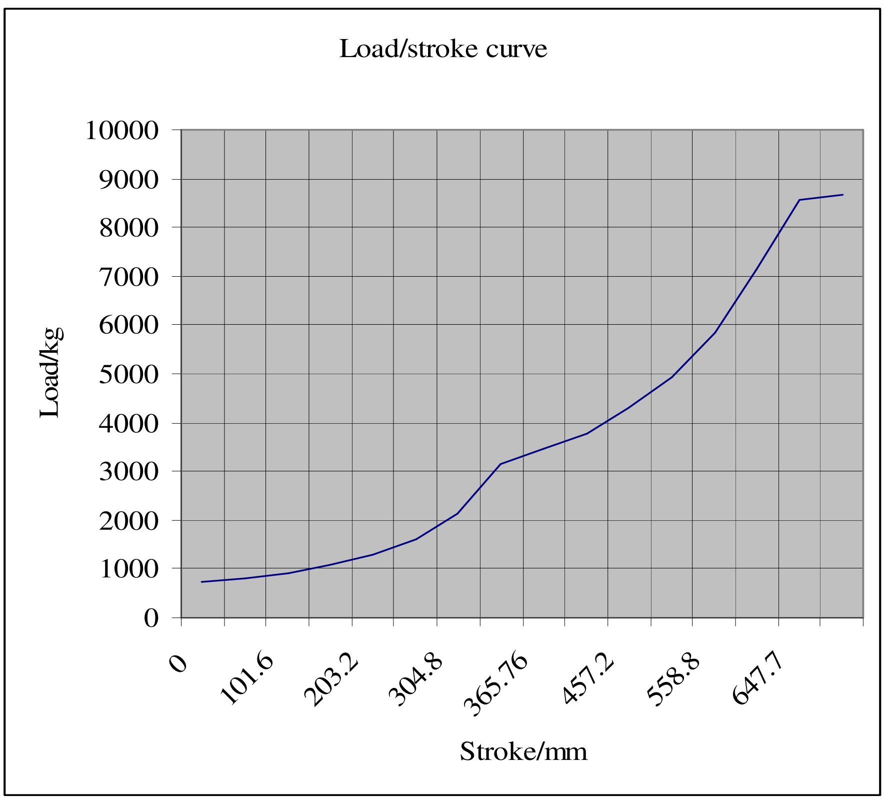
Oleo Pneumatic Double acting shock absorber to absorb gusts

<u>Assumptions:-</u>

Fully compressed ratio	= 3/1(same as single-acting)
Fully extended ratio	= ¼
Static pressure	= 1 500 psi
Break over point	= at 1.2 g
Stroke to static	= 50% - 60% (taken as 55% as an average value)

Stroke/mm	Stroke/in	Volume/cubic in	Pressure/psi	Load/lb	Load/kg
0	0	77.07	375	1588.98	720.75
50.8	2	68.6	421.33	1785.29	809.8
101.6	4	60.12	480.72	2036.93	923.94
152.4	6	51.65	559.6	2371.15	1075.53
203.2	8	43.17	669.43	2836.6	1286.66
254	10	34.7	883	3529.37	1600.89
304.8	12	26.22	1102.1	4670	2118.28
355.6	14	17.8	1628.29	6899.53	3129.57
365.76	14.4	16.05	1800.19	7627.9	3459.96
406.4	16	72.05	1969.25	8338.39	3782.23
457.2	18	63.58	2231.55	9449.03	4286
508	20	55.11	2574.46	10901	4944.61
558.8	22	46.64	3041.88	12880.19	5842.36
609.6	24	38.17	3716.7	15737.53	7138.42
647.7	25.5	31.8	4458.49	18878.52	8563.15
650.24	25.6	31.9	4518.61	19133.11	8678.63

Calculation of load stroke for nose gear double acting shock absorber



. Graph for the nose gear double-acting shock absorber

From the graph there are two identical curves which show the break over point.

- Nose gear stroke = 0.65m

Main gear double-acting shock absorber design

Assumptions:-

Fully compressed ratio = 2/1(for main gear it's different from above)
Fully extended ratio = 1/3 (different from above)

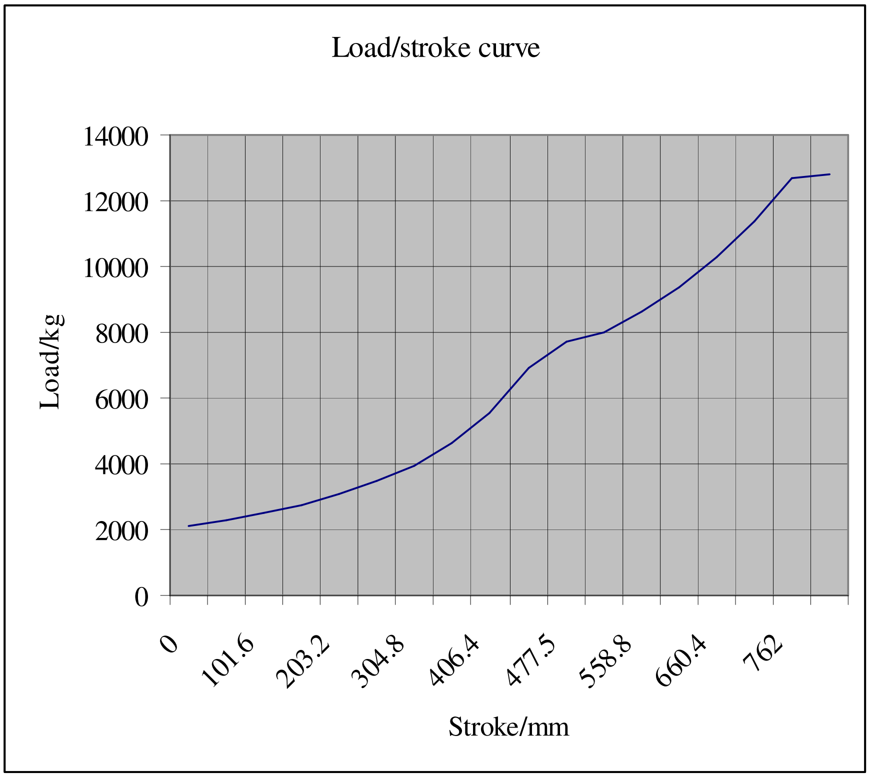
- The compression ratio and the extended ratios have become smaller than the single-acting shock absorber and this is an advantage of double acting shock absorber.

Static pressure = 1 500 psi
Break over point = at 1.2 g
Stroke to static = 50% - 60% (taken as 55% as an average value)

Stroke/mm	Stroke/in	Volume/cuin	Pressure/psi	Load/lb	Load/kg
0	0	243	500	4694.38	2129.33
50.8	2	225.18	541.69	5085.83	2306.89
101.6	4	206.4	590.97	5548.51	2516.76
152.4	6	187.63	650.12	6103.8	2768.64
203.2	8	168.85	722.42	6782.59	3076.53
254	10	150.07	812.81	7631.25	3461.48
304.8	12	131.29	929.05	8722.66	3956.53
355.6	14	112.52	1084.1	10178.35	4616.82
406.4	16	93.74	1301.26	12217.23	5541.64
457.2	18	74.96	1627.22	15277.56	6929.78
477.5	18.8	67.45	1808.42	16978.79	7701.45
508	20	253.64	1879.95	17650.43	8006.1
558.8	22	234.86	2030.26	19061.61	8646.2
609.6	24	216.08	2206.69	20718.04	9397.54
660.4	26	197.31	2416.7	22689.76	10292
711.2	28	178.53	2670.88	25076.24	11374.39
762	30	159.75	2984.82	28023.75	12711.36
764.3	30.09	158.91	300.69	28172.77	12778.95

Values for loads strokes for main gear double-acting shock absorber

According to the calculation the Load/stroke curve can be obtained as in figure below



Load/Stroke curve for main gear double-acting shock absorber

From the graph the two identical curves can be seen which is due to the break over point.

- Main gear stroke = 0.76m

Final strut sizing for double acting shock absorber

Gear type	Length/m	Static margin/m	Break over point/m	Diameter/m
Nose gear	0.65	0.35	0.37	0.41
Main gear	0.76	0.44	0.48	0.66

Discussion

In completing this project there are several problems to face. The first thing was that in all the reference books the units were given in British standards but this particular project was to carried out with SI units. So basically throughout this project all the calculations can be seen in the British standard units but the ultimate answers are kept on SI units in order to accomplish the reader.

The main aim of the project has been achieved; that is to land on the rough field with all the appropriate technology. But at the same time this still has a problem on operating on the rough field when the surface becomes muddy on a rainy day, which has not been achieved by this project.

As concluding the overall of the project it is still a successful design.

ACKNOWLEDGEMENT

It would have been an unexpected task of designing an undercarriage for a heavy air craft of 14 tonnes and which could be capable of rough field operations for an undergraduate engineering student if not for the proper guidance given by the well experienced Professor John E. Allen. At the beginning of the design it appeared to be difficult and not a very friendly task but at the end, the task has become an enjoyable piece of work with the guidance of Professor John Allen. The way he guided me through out the project has made myself at last a designer (of qualities which a designer should posses). So I would like to take this opportunity to thank my Professor being my project supervisor, who helped me in all the ways by giving me all the specifications of the project and all the information of text books which a design student should read and start their career as a designer.

At the same time I would like to give a special thank to all Kingston University, Penryn Road, library staff, who helped me to find out all necessary books for the project and keeping references available.

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