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Technical Manual – Section 11
Lytag Vehicle Arrestors

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INTRODUCTION

A Lytag Vehicle Arrestor (LVA) is a specially prepared bed of un- compactable material, designed to decelerate wheeled vehicles or aircraft at a controlled rate and bring them to a halt minimising danger to the occupants or damage to the fabric.
They are used to form escape routes on steep gradients, roundabouts, dangerous bends and runway overshoots.

Examples of vehicle arrestor beds can be found at many locations around the UK including the approach to Dover Dock; Whitby, North Yorkshire; Hemel Hempstead.
Silverstone, Rockingham, Donnington Park race circuits, and the Ascari Race Resort in Spain have Lytag arrestor beds. Manchester, Southampton and Southend airports have Lytag arrestor beds at the end of their runways. There are also examples of highway arrestor beds internationally, e.g. Greenbank, Freemantle, Western Australia

LVAs have been in use and undergone intensive testing since the 1960s. This document includes many quotes from referenced sources covering this work to highlight the key design factors. These references are italicised for clarity.

The references rely heavily on early work performed by the Transport and Road Research Laboratory for road vehicles, and the Royal Aircraft Establishment for aircraft. Many of the general comments apply irrespective of the “object” to be stopped.

The key physical properties of Lytag are:-

- Rounded shape so it doesn’t compact over time and lose its ability to effectively arrest vehicles
- Density is half that of gravel which makes it more cost effective and environmentally considerate to transport to site.
- Resistant to weathering and frost so it doesn’t degrade over time
- Fire resistant
- Chemically inert

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What is an arrestor bed

"On existing hills where there is a history of accidents involving runaway vehicles consideration should be given to the provision of arrestor beds." i
"The purpose of arrestor beds is to stop, without serious injury or serious damage to vehicles or to adjacent property or other road users, those vehicles whose brakes fail on long down hill gradients. The gravel filled type arrestor bed is the most effective permanent means of stopping runaway vehicles. A lightweight aggregate fill material eg Lytag is preferred." ii
"Even when no brakes are used arrestor beds produce decelerations similar in magnitude to those given by efficient brakes on a dry road." iii

GENERAL DESIGN CONSIDERATIONS

Type of material

"Initial Road Research Laboratory tests have shown that vehicles which experience brake failure can be safely stopped if they are steered into beds of loose gravel. It was established that small stones decelerate vehicles better than large stones, and that round stones are more efficient than angular stones. An artificial round aggregate (LYTAG) was shown to be as good as small round stones." iv
"When a vehicle uses the facility, bed material may be thrown onto the carriageway and this may constitute a nuisance or danger to pedestrians and traffic. Its prompt removal by emergency road sweeping is essential. Use of lightweight bed material .... may help to reduce damage during the period before the carriageway is swept." v
"Other rounded aggregates from both natural and artificial sources would also need prompt removal with the possibility of greater window glass damage coming from the heavier aggregates." vi

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Compaction

"To achieve a high deceleration rate it is necessary that vehicle tyres sink into the bed material. Rounded uncrushed gravel or similar artificial lightweight aggregate has performed satisfactorily in tests and should be used in preference to angular gravel (i.e. crushed rock) or sand, which tend to restrict wheel penetration and compact with time and usage." vii
"Raking is necessary to reshape and smooth the surface and to loosen the aggregate after each use." viii
Unlike most naturally occurring aggregates Lytag is rounded. This is due to the manufacturing process. This property means that it does not compact over time so it is always ready for use. An analogy would be a floor covered with a thick layer of ball bearings. If you try to walk across them you sink as the bearings "roll" over each other and displace. It is this principal that makes a Lytag arrestor bed so effective.

Lytag arrestor beds require little maintenance.

Fire resistance

Lytag reduces the danger from fuel fires after a crash.
"In this test two samples of dry (m.c. = 0.2%) and damp (m.c. = 25.3%) Lytag each 24" x 24" and 18" deep were prepared. 2.5 gallons of petrol were poured over each and allowed to soak in for ten minutes. Attempts were then made to ignite the petrol by matches and balls of burning paper. A single match ignited the petrol on the dry Lytag which burned quietly and slowly until all the surface vapour was used up. On the other hand it was impossible to ignite the damp Lytag. The dry Lytag showed no physical deterioration other than blacking due to the burning." ix

Frost resistance

Lytag is not damaged by frost. Due to its good thermal insulation properties only a thin, easily penetrated, surface crust will form even in the most severe winter conditions. The arrestor bed is therefore always ready for use throughout the year.

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DIMENSIONS OF AN ARRESTOR BED

Dual track beds (wide enough to accept the wheels on both sides of the vehicle)

Depth

For an arrestor bed to be completely effective it has to be deep enough to allow the wheels of the vehicle to sink into it. Vehicle momentum is destroyed by the displacement and banking up of the media. The density and shape of
Lytag gives a good balance between depth of penetration and density of aggregate for optimum deceleration conditions.
"Where entry velocities are less than 75km/hour, vehicle deceleration is
significantly higher for beds which contain greater depths of bed material, whereas above 75km/hour decelerations tend to be independent of bed depth. Beds should have depths between 300mm and 450mm with the depth gradually increasing over an initial length in order to provide for smooth vehicle entry. The greater (450mm) depth gives around 50% higher stopping ability than the minimum 350mm provision and should be considered where
bed length is restricted." x
"The (Lytag test) bed was made deeper (at 0.6m deep) than those with natural gravel (0.3m deep) because it was felt that vehicle wheels might sink further into the lightweight aggregate, which has a bulk density only one-half that of similar sized gravel."
"The tests in different depth patterns indicated that a constant depth arrestor following a tapered entry had an advantage over one with a continuous upward taper in that it gave a higher mean deceleration and a lower peak deceleration and was thus less likely to cause nose-wheel leg failure."
"For the sintered fuel ash pellets, (i.e. Lytag) having much lower density and internal friction than gravel, an equivalent depth of 24 in (630mm) was considered a likely minimum for the arresting of large aircraft." xi
"It thus appears that the depth of bed of arrestor material in a roadside installation (for dual track beds) should not be less than 0.38m and should preferably be about 0.45m." xii

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Length

“The length of a bed which will be required to halt runaway vehicles is dependent on the predominant vehicle type, the likely speed of entry into the bed: the type of aggregate used and the arrestor bed slope.” xiii

Efficient brakes on a dry road produce a mean deceleration of about 0.5g. Using no brakes, deceleration in an LVA produces rates of 0.6g. With brakes applied, and the wheels locked on entering the bed, the rate is increased to 1.0g.

“The mean deceleration at 48km/hour of this deeper (Lytag) bed was 0.58g, nearly twice that obtained with a uniform depth of 1.9 - 1.27cm angular gravel.” xiv

It is significant to note that brakes which have faded through overheating may become able to lock the wheels of a vehicle on leaving the carriageway and entering the arrestor bed. Trials with various types of vehicle at various entry speeds indicate that the deceleration achieved is independent of entry speed or vehicle weight.

“The length of a dual track Lytag bed (i.e. both sets of wheels in the bed) to stop runaway vehicles can be found from the formula:-

$$L = \frac{v}{2g}$$ [xv] g = 0.6g. unbraked or 1.0g. braked

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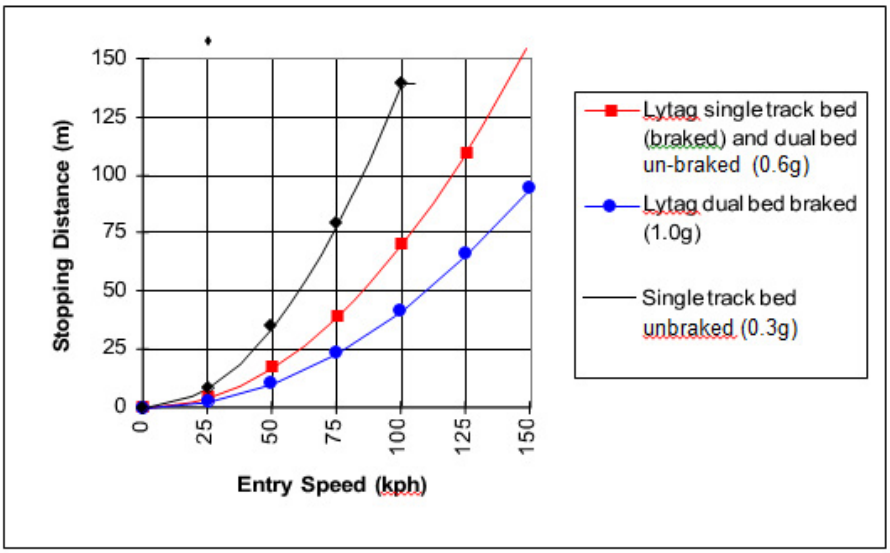
This is shown in the following graph, along with figures for Single Track Beds



Width

(for cars and lorries)..."in general a constant bed width of 4.0 - 5.0m is adequate." xvi

Single-track beds

In certain locations it is not possible to accommodate the width of dual track beds. In these situations a single-track bed can be used.
The lower rates of deceleration of single track beds can be compensated for by extending the distance alongside the carriageways. Stopping distances are shown in the graph above.

Recovery, service and maintenance

Following an incident, two-wheel drive vehicles will need towing out of the arrestor bed. Four-wheel drive vehicles should be capable of self-propulsion.

Spillage of Lytag should be swept clear immediately and the arrestor raked flat. It is then ready for immediate re-use.
Periodic raking is the only maintenance normally required, however application of weed killer will inhibit clogging by organic matter.

NOTES FOR DRAFTING SPECIFICATIONS

Dual track beds

The siting of the bed will be a function of the accident history at the proposed location. Lengths may be determined by reference to the graphs above, having assessed the most likely entry speeds. Once a vehicle enters the bed there is little or no steering response so the vehicle will continue in a straight line unless deflected by a high kerb or safety fence. Turning the wheels results in the steering assuming a “full lock” position which thus presents a larger “ploughing face”. This gives improved rates of deceleration.
Generally, width for dual track beds should be 4.5m. The Lytag bed should have a minimum depth of 0.4m plus adequate drainage to prevent flooding.
The carriageway edge of the excavation should be protected by a rumble strip or standard kerb laid on its side to provide some protection against accidental entry.
The excavation should be filled with Lytag granular material to within 75mm of the top.
The need for safety fencing to protect pedestrian footways will depend on the LVA location.
Warning notices should be erected to advise motorists - “Escape Lay By - Use in Emergency Only”.

Single track beds

In addition to the above, single track beds should be 1.4m wide with crash barriers mounted on a concrete kerb 150mm above the Lytag media level.

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Aircraft arrestors

Lytag media to be laid on the surface of the over-run for the full width of the runway.
The types of aircraft using the airport, and the length of over-run available, will determine the depth of the arrestor.

Lytag aggregate - supply and ordering

Lytag is available for delivery to anywhere in the UK or abroad.

For further information, including details of previous contracts, please contact the Lytag office.

References

i Department of Transport, Highways and Traffic Department Advice Note TA57/87, Roadside Features, Cl 6.2.1
ii DoT, TA 57/87, Cl 6.1. References
iii Road Research Laboratory, RRL Report LR264, Cl 8 iv Road Research Laboratory, RRL Report LR376, Cl 1 v DoT, TA 57/87, Cl 6.3.3.a
vi Road Research Laboratory, RRL Report LR376, Cl 5.7
viiDoT, TA 57/87, Cl 6.3.1.e
viiiRoyal Aircraft Establishment Technical Report 69001, Cl 5
ix Report by an independent company, Ground Engineering Limited, dated 11 December, 1968. Not published but available from Lytag on request.
x DoT, TA 57/87, Cl 6.3.1.d
xi Royal Aircraft Establishment Technical Report 71015, Cl 2.3.
xii Road Research Laboratory, RRL Report LR376, Cl 4.1
xiii DoT, TA 57/87, Cl 6.3.1.b
xiv Road Research Laboratory, RRL Report LR264, Cl 4.2 xv Road Research Laboratory, RRL Report LR376, Cl 4.1 xvi DoT, TA 57/87, Cl 6.3.1.c

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