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# MOTORCYCLES AND SAFETY SYMPOSIUM

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# MOTORCYCLE SAFETY: A SELECTIVELY ANNOTATED BIBLIOGRAPHY

## ABSTRACT

*This briefly annotated bibliography complements the paper 'User issues in motorcycle safety' presented at the ARRB/ADOT symposium on Motorcycle Safety held at ARRB in June 1976. The references are grouped into 12 categories. The Harvard referencing system is used throughout.*

## CATEGORIES ADOPTED

1. Safety measures
2. Data on accidents - motorcyclists, exposure and mileages
3. Legislation
4. Motorcycle and motorcycle user behaviour
5. Motorcycle noise
6. The motorcycle itself: inspection, physical characteristics, visibility and design
7. Motorcycles in a transport planning context
8. Motorcycle accident trauma
9. Motorcycle driver licencing
10. Motorcycle air pollution factors
11. Motorcycle training
12. Motorcycle helmets

## 1. SAFETY MEASURES

ALSOPP, R.E. (1966*a*). Possible effects on casualties of changes in the law governing driving by 16 year olds. TRRL Technical Note 64 (unpublished).

- an exploratory and indicative statistical analysis of the effects of restricting or increasing the range of vehicles which 16-17 year olds could drive and including the restriction to moped use which subsequently became law in U.K.

_____ (1967). Costs and benefits arising if all motorcyclists wore safety helmets. TRRL Report LR72, Crowthorne.

BENJAFIELD, C. (1974). Road hazards and the motorcyclist: memorandum submitted to the Minister for Transport. British Motorcycle Federation. 11 pp.

- skidding, roadworks, lighting, parking and security of HGV loads are all examined in detail: a legislative review is included, and recommendations made which stress that enforcement of existing laws should be the main emphasis.

CASSEL, A. and JANOFF, M.S. (1971). Effect of daytime motorcycle headlight laws on motorcycle accidents. *Highw. Res. Rec.* 377. pp. 53-63.

- accident records in four regulated U.S. States - Indiana, Montana, Oregon and Wisconsin, and four control States suggested substantial savings in accidents from headlamp usage legislation: a saving of up to $10 (U.S.) p.a. from U.S.-wide legislation was calculated (equal to the price of 4/5 headlamp bulbs, which is close to the likely consumption level to be induced by continuous daytime usage, and not accounted for in this paper).

CHANDLER, K.N. and THOMPSON, J.K.L. (1957). The effectiveness of present day crash helmets for motorcyclists. *Oper. Res. Q.* 8(2), pp. 63-71.

CHAPMAN, C.C. and CUMMING, R.W. (1976). The motorcycle accident problem. ARRB/ADOT Symposium: Motorcycles and Safety, June, Australian Road Research Board, pp. 164-179.

- a review of design measures directed mainly towards secondary safety with strong leanings on U.S. work, with the Australian design rules for braking discussed in some detail as an example.

FOLDVARY, L.A. and LANE, J.C. (1964). The effect of compulsory helmet wearing on motorcycle accident fatalities. *Aust. Rd Res.* 2(1), pp. 7-24.



INSTITUTE FOR ROAD RESEARCH (SWOV) (1975). Netherlands. Crash helmets for moped riders. Publication No. 1975-IE. 23 pp.

NORDIC SAFETY COUNCIL (1975). Headlights in daytime. Report 12. (45 pp.) Stockholm.

_____ (1974). Motorcycle and moped helmets. Report 8. 101 pp. Oslo.

- legislative factors studies for Norway, Finland, Sweden and Denmark, with full literature searches, indicated a probable net 25 per cent reduction in head injury risks through helmet wearing. Compulsory approved helmet use by both motorcycle and moped riders is recommended. The key factor is height of fall and not speed of vehicle: helmet use should not be compulsory within parking areas, petrol stations, etc.

NOORDZIJ, P.C. and PAAR, H.G. (1973). Helmets for moped drivers. SWOV (Stichting, Wetenschappelijk Onderzock Verkeersveiligheid), Voorberg, Nederland. Report 1973-2N. (23 pp.)

- attitudes to helmet use, legislation and comfort supplement, a study of helmet requirements for moped users.

SINGH, C., ROBSON, S.H. and TOOMATH, J.B. (1975*a*). Compulsory safety helmet legislation and motorcyclist accidents. No. 7 (N.Z.) Research Report 8. 15 pp.

- a before and after study, affected by fuel conservation measures in the 1974 (after) period, which casts doubt on the 40 per cent fatalities reduction noted for 1974. The results are however consistent with the reductions from the similar 1956 law which was applicable only at speeds in excess of 30 mph.

_____ (1975*b*). Motorcycle helmet and headlamp checks 1973. MOT (N.S.) Research Report 9. 10 pp.

- compliance rose from 74 per cent to virtually 100 per cent after the laws introduction; pillion passenger numbers reduced, and about 20-25 per cent of motorcyclists were found to be voluntarily using headlights in the daytime.

SMITH, D.I. (1975). An investigation to determine whether the daytime usage of motorcycle headlights and tail lights should be made compulsory in Western Australia. Road Traffic Authority, Perth, Western Australia. 31 pp.

TURTURICI, A.R. (1975). An evaluation of speed curtailing bumps. Public Works (106) 8, pp. 73-76.

- discomfort is reduced by speeding up over bumps, and these present a specific hazard to bicycles and motorcycles.

VAUGHAN, R.G. (1976). A study of motorcycle crashes. ARRB/ADOT Motorcycles and Safety Symposium. Australian Road Research Board, pp. 24-58.

- analysis of a very detailed questionnaire added to police reports of 1511 accidents in N.S.W. between May - July 1974. 40 deaths and 1044 injuries. A further 427 accidents in the period were covered in lesser detail. The bank of data established is used to assess a range of counter-measures including tyre and lighting factors.

WOLTMAN, H.L. (1974). Some day and night visual aspects of motorcycle safety. *Transp. Res. Rec.* No. 502, pp. 1-8.

## 2. DATA ON ACCIDENTS - MOTORCYCLISTS, EXPOSURE AND MILEAGES

ALEXANDERSSON, S. and LEKANDER, T. Motorcycle accidents resulting in personal injuries 1970. Swedish Road Safety Office, S-171 20 Solna, Fack, Sweden.

ALSOPP, R.E. (1966*b*). A pilot study of motorcyclists in a county and a county borough. TRRL Technical Note 114 (unpublished).

- a log book questionnaire study report, including accident involvement. About 12 per cent of owners said machines out of use when they received the questionnaire, and the lack of full lists of past machines moved made it impossible to estimate the effect of a limitation to 250 cc machines for learners.

AUSTRALIAN COMMONWEALTH BUREAU OF STATISTICS (1971). Survey of motor vehicle usage - twelve months ended 30th September 1971.

- the most recent data on vehicle miles disaggregated by vehicle type, yields an accident rate for motorcycles of 7 times that of the average for all vehicles.

AUSTRALIAN EXPERT GROUP ON ROAD SAFETY (1972). The road accident situation in Australia. A national review. A report to the Minister for Shipping and Transport by the expert group on road safety. Australian Government Printing Service, Canberra.

- a summary coverage of all aspects of road safety, with numerous specific recommendations on legislation included.

AUTOSAFE (undated). Saving more cyclists. Roseberry, Australia.

- evaluation of the patterns of injury in motorcycle collisions in Southern California. Sources of injury being the machine, road surface and object struck. The ejection modes are considered, pillion passenger protection by driver was noted, and a leg protection frame and air bag concept advanced.



BARRY, P.Z. (1970). The role of inexperience in motorcycle crashes. University of North Carolina, Highway Safety Res. Center. R & D. Rpt. 1970-4. (28 pp.)

- borrowers of machines are compared to owners: borrowers were seen to have higher night time crash rates than owners, to be travelling slower in two vehicle collisions, and to be more likely to be legally charged in an incident.

BYGREN, L.O. (1974). The driver's exposure to risk of accident. *Scand. J. Soc. Med.* 2(2), pp. 49-65.

- a postal questionnaire survey of three groups. Youngest and oldest had lower mileages, used mopeds and drove in spare time. A large part of the accident differences was explained by exposure to risk, as were traffic offences.

CETE (1972). Etude du plan de circulation de Toulon - analyse des accidents 1972. 20 pp. Aixen Provence.

- a three year survey of accidents by mode, time of day and person involvement with specific pedestrian and two wheeled vehicle differentiation.

ECE (1974). Statistics of road traffic accidents in Europe, 1973. 97 pp. United Nations Economic Commission for Europe.

ECMT (1974). Report on road safety problems concerning two wheeled vehicles. CM(74) 14 Final. 21st Annual Report and Resolutions of the Council of Ministers. OCDE, 2 Rue Andre Pascal, Paris 75775. France. pp. 82-119.

- a comprehensive cross comparison of European statistics for two wheeler use and safety, with legislative comment and appraisals, making recommendations for safety measures with the explicit recognition of the positive social role of motorcycles.

FOLDVARY, L.A. (1965). Analysis of age and experience of responsible and non-responsible drivers involved in motorcycle v. other motor vehicle collisions in Victoria 1961 and 1962. *Aust. Rd Res.* 2(3), pp. 43-50.

———— (1973). A review of pedestrians, pedal cyclists, and motorcyclists in relation to road safety. Australian Department of Transport. Report NR/19. Canberra. Aust. Govt. Print. Services.

- suggests that four years is the period needed to gain enough experience to become a low risk motorcyclist.

FRENCH : DELEGATION A LA SECURITE ROUTIERE (1974). Dossier Statistique deux-roues. 20 pp. Paris.

- covers both use and safety factors for cycles and motor-cycles with cross-national comparisons within Europe.

GENDAMERIE NATIONALE (1973). Statistique annuelle des accidents de la circulation routiere constates en metropole. 31 pp. Paris.

- a special analysis of the net reduction in accident rate evident in 1973, with full HGV and two-wheeler details in each tabulation.

GODLEY, M.J. (1972). The incidence of burst tyres prior to injury accidents on the M1 and M4 motorways. TRRL Report LR498, Crowthorne. 9 pp.

- 36 per cent of all two wheeled vehicles incurred a burst tyre prior to accident involvement, the highest of all types of vehicles.

GRIFFIN, L.I. (1974). Motorcycle accidents: who, when, where and why. Chapel Hill, North Carolina, Highway Safety Res. Center. University of North Carolina, 1974. 45 pp.

HADDON, W. (1972). Road safety problems and actions: the U.S. approach. National Road Safety Symposium, Canberra. Proceedings pp. 579-612. ADOT, Canberra.

- includes motorcycle safety.

HARANO, P.M. and PECK, R.C. (1968). The California motorcycle accident study: Driver and accident characteristics. California State Dept of Motor Vehicles. Report 28.

- inexperience and youth emphasised, with the consequent proposal to concentrate on driver training.

HENDERSON, J.M. (1970). Deaths on motorcycles. A study of 120 fatalities. Traffic Accident Research Unit. D.M.T., Sydney. Report 7015.

- over 50 per cent were 16-20, plus 25 per cent 21-25 years of age.

HOOPER, P.E. and SINCLAIR, D.J. (1973). Motorcycle accident study. Report to Commonwealth Department of Transport, Canberra. (P.A. Management Consultants).

- accident involved vehicles 1972-3 in South Australia provided 1200 vehicles in a usable sample. Government, police and company motorcycles were omitted, which excluded a further 700 of this sample which would otherwise have been usable.

JACOBS, G.D. and HUTCHINSON, P. (1975). A study of accident rates in developing countries. TRRL Report LR546, Crowthorne. 33 pp.

- motorcycle ownership shown to correlate with ownership rate and ratio of fatalities to casualties.



JEFFCOATE, G.O. and GARWOOD, F. (1956). A review of information on motorcycle accidents with special reference to the age of motorcyclists. Road Research Laboratory. RN/2775/GOJ/FG.

- an early indication of the over-involvement of larger machines in accidents.

JOHNSON, H.D. and TANNER, J.C. (1965). Casualty rates to motorcycle riders. TRRL Technical Note TN26. Crowthorne. (unpublished).

- early evidence in confirming that the mileage rate of involvement for motorcycles exceeds that for cars.

_____ (1972). Accidents involving two wheeled vehicles at roundabouts. TRRL Technical Note TN705. Crowthorne. (unpublished).

- pedal cycles are found to be specially at risk, but motorcyclists only a little more at risk than average, and that only by day.

JOHNSON, P.W. (1972). Travel by motor vehicles in 1970. *Public Roads* 36(2) 12, pp. 268-9.

- vehicle miles by all U.S. States, and by vehicle types including motorcycles.

JOHNSTON, I.R., MILNE, P.W. and CAMERON, M.H. (1976). Age experience and motorcycle engine capacity in motorcycle accidents. ARRB/ADOT Motorcycles and Safety Symposium, June, Australian Road Research Board, pp. 1-23.

- based on 1203 accidents in South Australia in 1973; 713 accidents to Government, police or company motorcycles were excluded. The remaining sample showed high involvement of riders under 25 and larger machines.

KRAUS, J.F., RIGGINS, R.S., DRYSDALE, W. and FRANTI, G.F. (1973). Some epidemiological features of motorcycle injury in a Californian community. Second International Congress on Automotive Safety: Motorcycle and recreational vehicle safety. San Francisco. July 1973.

MAPES, R.E.A. and DRAJDA, R.H. (1973). Report of a survey to determine motorcyclists actual mileage and accident rate. Keele University, U.K. (25 pp.)

McLEAN, A.J. (1971). The other road users: the pedestrian, cyclist and motorcyclist. Proceedings of the third triennial Congress of the IAATM on medical and related aspects of motor vehicle accidents. Ann Arbour, 1969. University of Michigan, U.S.A. pp. 85-94.

MENZIES, I.E. (1968). Some social and psychological aspects of road safety. London, Tavistock Institute of Human Relations. 80 pp.

- a qualitative discussion of a sub-set of car and motorcycle users, with substantial speculative elements. Concentrates on attitudes of, and between, different classes of road user.

MESSITER, G.F. (1972). An assessment of measures to reduce cyclist and motorcyclist accidents. Traffic Accident Research Unit, D.M.T., N.S.W. R & D Report 1972-12 (32 pp.).

- inexperience of motorcycle riders is emphasised as a high risk factor. 80 per cent of all reported motorcycle crashes involved injury in a N.S.W. study, against 25 per cent of all reported road vehicle accidents.

MUNDEN, J.M. (1964). The variation of motorcycle accident rates with age of rider and size of machine. *Int. Road Safety and Traffic Review.* Vol. xii(1). OTA. London.

- this detailed note covers age of machine as well, and provides a full cross analysis of age, age of rider, involvement rate, and size of machine. The high rates of involvement of young (under 25) riders and large machines show these to be longstanding trends.

NARANJO, D. *et al.* (1971). Accidents caused by people not needing a driving licence (pedestrians, cycle, moped and cart drivers and cattle loaders) involved in traffic accidents.

- this work also covers violations incurred by non-licence holders in Spain.

NICHOLAI, A.M. (1970). The motorcycle syndrome. *Am. J. Psychol.* 1970(05) 126(11). pp. 1588-95.

- an in depth study of accident prone motorcyclists suggests an ego defect syndrome, and suggests general clues to understanding accident prone drivers of other vehicles.

NOORDZIJ, P.D., VIS, A.A., BLOKPOEZ, A. and ELDERVEEN, G.C. (1973). The moped driver and traffic safety. SWOV, Voorberg, Nederlands. Report 1973-1N. (54 pp.)

- 2 per cent of moped injury accidents were fatal in 1970; young drivers, old drivers and women have high accident quotients, and accident quotients have been increasing in big cities.

O.E.C.D. (1975). Young driver accidents. Organisation for Economic Co-operation and Development. Paris.

- covers a number of motorcyclist studies, confirming the widespread preference of young males for large machines and the coincidence of young riders and large machines as the highest risk group.

O'MARA, J.J. (1971). Motorcycle accidents. Proc. third triennial Congress of the IAATM on medical and related aspects of motor vehicle accidents. June 1969. Ann Arbour. pp. 85-94.



RAEDER, P.A. and NEGRI, D.B. (1969). An evaluation of motor vehicle accidents involving motorcycles - severity, characteristics, effects of safety regulation. New York State Department of Motor Vehicles. Research Report 1969-12. (58 pp.)

- indicated that pillion passengers had a 20 per cent greater chance of death in an accident.

REISS, M.L. and HALEY, J.A. (1968). Motorcycle safety. Airbourne Instruments Lab. N.Y. NTIS Report PB/178/332.

- U.S. confirmation of high involvement rate of inexperienced riders.

ROBERTSON, J.S., McLEAN, A.J. and RYAN, G.A. (1966). Traffic accidents in Adelaide, South Australia. Special Report No. 1. Australian Road Research Board.

- included 66 motorcycle accidents, which occurred mainly in 2nd to 5th years of riding experience.

SCHUMAN, S.H., PELZ, D.C., EHRLICH, N.J. and SELZER, M.I. (1967). Young male drivers: impulse expression, accidents and violations. *J. Am. Med. Assoc.* 200(12), pp. 102-6.

- this group dominates all present motorcycle usage, and are particularly vulnerable to peer group pressures in their behaviour.

SCOTT, C. and JACKSON, S. (1960). Accidents to young motorcyclists: a statistical investigation. Social Survey Report SS227B. Central Office of Information, U.K.

- motorcyclists with less than 6 months experience had about twice the accidents per head of those with more than 6 months experience.

SMEED, R.J. (1972). The statistics of road accidents. Presented at 3rd International Symposium on Urban Traffic. Budapest 1972. University College London. (25 pp.)

- the product of distances travelled by each type concerned in two vehicle accidents varies with the number of such accidents by a factor which ranges from 0.5 for pedal cycles to 1.02 for motorcycles.

SPECA, J.M. and COWELL, H.R. (1975). Mini-bike and motorcycle accidents in adolescents. *J. Am. Med. Assoc.* 232(1). pp. 55-6.

- severe injuries involving 9-16 year olds suggest a new pattern of such injuries of 'epidemic proportions'.

U.S. - DEPARTMENT OF TRANSPORT (1973). Estimate of the 1973 motor vehicle registrations. U.S. - Department of Transport Report: Statistics 1973-09-27 (2 pp.). Washington D.C.

- includes trucks, buses, cars, motorcycles registered in each State.

WALLER, P.F. (1972). An analysis of motorcycle accidents with recommendations for licencing and operation. University of North Carolina. R & D Report 1972-08. (20 pp.)

- 62 per cent of car/motorcycle incidents were car drivers' fault in left turns; in 29 per cent the motorcyclist in following too closely. Single vehicle and passenger statistics are also given.

WATSON, P.M.F. and LANDER, F.J.W. (1973). Motorcycle accidents and injuries. Conference on vehicle safety legislation - its engineering and social implications. Cranfield Institute of Technology. Institute of Mechanical Engineers.

- on the spot data from TRRL team showed that in less than half of the motorcycle accidents were the motorcyclists at 'fault', and that more accidents occurred in wet conditions than would be expected by chance. The potential effect of safety helmet legislation is updated to 1972, and the TRRL safety programme for motorcycles is outlined. Illustrations of the Mullard/TRRL antilock equipped motorcycle are included.

WIDEN, S. (1973). Traffic accidents involving motorcycles 1970. State Traffic Institute Report 35. (48 pp.). Stockholm.

- heavy motorcycles were involved in twice as many accidents as small ones. Three quarters of all accidents were in urban areas; 50 per cent resulted in severe personal injuries, and over 85 per cent occurring in the summer half year (April - September). For light motorcycles, 3 in 4 were between 16-17 years old. Includes comparisons with other reports, and a discussion of speeds and flows of motorcycles.

## 3. LEGISLATION

ANON (1972). New motorcycle facts issued. Traffic Safety 71(12), 18 pp.

- U.S. motorcycle registrations, accidents and deaths with details of State licencing and helmet laws.

_____ (1974). The 'advent of the motorcycle'. 1 - Japan: an example worth following. 2 - and elsewhere: in the Netherlands. La Prevention Routiere Internationale 1974(8), pp. 6-12.

- in 1970-71 the increase in accidents in Japan was 80 per cent in the 16-19 age group. Large machines were more involved than small ones, and 68 per cent of fatalities were head injuries. An 18.3 per cent decrease in 1972 was attributed to driver education programmes. In Holland 47 per cent of fatalities were under 25, and 80 per cent had head injuries.



_____ (1973). The motor vehicle (construction and use) regulations 1973. HMSO, London. Standard 1977 No. 24, 113 pp.

_____ (1975). Virginia: Fairfax county enacts noise control law setting sound limits for motor vehicles, quiet hours. Noise Regulation Reporter No. 35, 29 pp.

- a motorcycle at less than 35 mph is limited to 82 dBA, over 35 mph to 86 dBA, and this is matched to trucks at 86, 90 dBA. Loading/unloading of trucks between 9 p.m. - 6 a.m. is forbidden, and environmental standards of 55 dBA for residential areas, 60 dBA for commercial zones, and 72 dBA for industrial areas are stated.

JOHNSON, H.D. (1967). Benefits arising in 1967 if all motorcyclists wore safety helmets. TRRL Technical Note TN243. Crowthorne. (unpublished).

- uses the method of LR72 (Alsopp), and suggested the saving of 150 fatalities and 550 serious injuries might be achieved.

POSTON, H.W. (1975). Timetable and obstacles for source control in the city of Chicago. TRB Special Report 152. pp. 44-45.

- the most difficult problems since legislation was introduced in 1971 has been motorcycle noise and getting recognition from the enforcement courts of the seriousness of noise violations in their lives: emergency vehicle noise has also presented problems, leading to consideration of further specific legislation.

SOUTH AFRICAN NATIONAL ROAD SAFETY COUNCIL (undated). The motorcyclist as road user. Pretoria, S.A. (26 pp.)

- summarises the South African legislation affecting motorcyclists, licencing, carriage of passengers and articles, protective clothing and vehicle design requirements.

_____ (undated). The passenger as road user. Pretoria, S.A. (14 pp.)

- summary of South African legislation on passengers in cars, and on bicycles and motorcycles.

TOYNE, C.C. (1973). Motor vehicle technical regulations: a guide to the motor vehicles (construction and use) regulations and the road vehicles lighting regulations. Lefton Engineering Services, London. (196 pp.)

- this book is aimed at giving an understanding of the 1973 motor vehicles (construction and use) regulations and the 1971 road vehicles lighting regulations, including type approval, noise, seat belts and laden weights.

## 4. MOTORCYCLE AND MOTORCYCLE USER BEHAVIOUR

HARTMAN, C.H. (1974). Motorcycle operator task analysis research. Am. Assn for Auto. Medicine. Proc. pp. 440-444.

- the U.S. Motorcycle Safety Foundation, Inc. course for the beginning rider, comprising student text and work books and teacher's guide.

LEWIS, R.E.F. and CUNNINGHAM, W.R. (1953). Hand signals versus turning indicator for motorcyclists. Medical Research Council, Cambridge, U.K. Applied Psychological Unit. APU193/53.

- emphasises the importance of signal unit separation, and the need to establish a reference w.v.t. the rear light at night.

MORTIMER, R.G. and JORGENSEN, C.M. (1975). Comparison of eye fixations of operators of motorcycles and automobiles. SAE 750363. 6 pp.

- the effect of road edge delineation, road geometry, and the differentials between motorcycle and car drivers were compared. The need for special headlight designs for motorcycles was deduced, in terms of their close foreground and edge delineation requirements.

ONSER (1970). Knowledge of road signs. R & D Report 1970. Paris. 96 pp.

- covered 1600 French pedestrians, motorcyclists, and car drivers: the results are given for each group separately.

RITCHIE, M.L., HOWARD, J.M., MYERS, W.D. and NATARAJ, S. (1972). Further experiments in driver information processing. Proc. 16th Human Factors Society Meeting L.A. 1972. Paper 1972-10. pp. 34-39.

- insignificant differences were found between motorcycle and car drivers for the day and night and advisory speed variables.

WARDLE, M. (1976). Motorcyclist attitudes to some road safety counter-measures. ARRB/DOT Symposium: Motorcycles and Safety. June. Australian Road Research Board. pp. 157-163.

- 74 Victorian motorcyclists interviewed. Counter-measures suggested by the motorcyclist were mainly on design improvements, and 60 per cent voluntarily used headlights during the day. The most acceptable measures were driver training and daytime headlight usage.



## 5. MOTORCYCLE NOISE

BOENSCH, H.W. (1971). Noise from motorised two wheeled vehicles. Kampf des haern. 1971(18) 6, pp. 145-150.

- comparative statement of noise reduction measures for motorcycles and cars, and comparison between noise measurements of 1950-51 with 1970-71 to assess the noise reduction steps taken over 20 years.

CLOSE, W.H. and WESLER, J.F. (1975). Vehicle noise sources and noise suppression potential. TRB Special Report 152. pp. 14-33.

———— (1973). Highway noise sources. *Highw. Res. Rec.* 448, pp. 5-11.

- the variations of intake, exhaust, engine, and chain noise with speed are given for cars, trucks, busses and motorcycles with possible remedial measures.

DE BRABANDER, L. (1973). Detection and measurement of noise emitted by vehicles. Journees Internationales de la securite routiere 1973-11(8) 8, 17 pp.

- documents the enforcement strategies to switch to an in-use policy for noise testing, and covers 2 years practical experience of the regulations in Belgium.

LYON, R.H. (1973). Lectures in transportation noise. Grozier, Mass. U.S.A. 259 pp.

OLSON, N. (1972). Survey of motor vehicle noise. *J. Acoust. Soc. Am.* 1972-11 (52) 5, pp. 1291-1306.

- statistical aggregation procedures and results for cars, LGV, MGV, HGV, Artics, buses, cement mixer trucks, and motorcycles.

ROE, G.E. (1974). The silencing of a high performance motorcycle. *J. Sound. Vibn* 1974-03-08 (33) 1, pp. 29-39.

- exhaust noise from a 750 cc twin was reduced from 98 dBA to 86 dBA under European test conditions without significant power loss. Induction and exhaust measures were taken (12 dBA and 20 dBA respectively) and mechanical noise determined the noise level of 86 dBA.

RUDOLF, E. (1973). The control action of the vehicle industry to the fight against noise. OESTERR. ING-Z. 1973-01(16) 1, pp. 14-17.

- structural features of motorcycles aimed at noise reduction. The role of standardised legislation within Europe is stressed as being essential to permit manufacturers to install such measures on the production line.

TUV (1971). Noise abatement. TUV, 1971(12) 8, pp. 245-248.

- a series of abstracts from the conference on traffic noise. (April, 1971: Bad Godesburg), includes structural steps to reduce motorcycle noise.

WIGAN, M.R., SOUTER, H.J., and INGLETON, I.M. (1974). Noise and air pollution in Coventry. TRRL (unpublished).

- showed that motorcycles did not warrant special distinction within the general traffic stream in the estimation of kerb side traffic noise levels, as a result of a range of measurements taken at major and minor sites in Coventry, U.K.

## 6. THE MOTORCYCLE ITSELF: INSPECTION, PHYSICAL CHARACTERISTICS, VISIBILITY AND DESIGN

AUTOMOBILE MANUFACTURERS ASSOCIATION (1971). Vehicle inspection handbook. Detroit. 1971-06, 106 pp. (Also MVMA of U.S. Report 1974-02 unpaged).

- specifically includes motorcycles.

BOTHWELL, P.W. (1974). Motorcycle crash tests. Jim Clark Foundation, 103 pp.

- reports on a series of 30 mph crash tests simulated on the MIRA linear motoring. Fuel tank, handlebar, and lower limb vulnerability highlighted in graphic form.

——— KNIGHT, R.E. and PETERSON, H.C. (1971*a*). Dynamics of motorcycle impact, Vol. 1. Summary report - results of crash test program and computer simulation. Univ. of Denver, Denver Research Institute. R & D Report No. DR1 2574. 50 pp.

- a series of 27 crash tests using 50 per cent anthropometric dummies: includes computer simulation results and overall crash test program digest.

——— KNIGHT, R.E. and PETERSON, H.C. (1971*b*). Dynamics of motorcycle impact, Vol. 2. Motorcycle crash test program. Denver, Colorado, University of Denver, 1971. Univ. of Denver, Denver Research Institute. R & D Report No. DR1 2574. 219 pp.

- crash results cover features of both motorcar and motorcycle design which are likely to increase hazard to motorcyclists: proposed safety standards are however proposed only for motorcycles.

——— and PETERSON, H.C. (1973). Dynamics of motorcycle impact. Second International Conference on Automotive Safety: Motorcycle and Recreational Vehicle Safety. Paper 73035.



BRITISH STANDARDS ASSOCIATION (1972*a*). Specification for tyres and wheels. Pt. 1: Tyres. Standard 1972: BS:AU:50, 62 pp. London.

- includes motorcycle and scooter tyres.

——— (1972*b*). Repairs to tyres for motor vehicles. Standard 1972: BS:AU:159, 14 pp. London.

- includes only on-the-road tyres for motorcycles and scooters.

CASSEL, A. and JANOFF, M.S. (1971). Effect of daytime use of motorcycle headlights and tail lights on motorcycle noticeability. Washington D.C., Highway Research Board. *Highw. Res. Rec.* 377, pp. 40-52.

- the effect of head, tail and dual front and rear amber lights was studied. Headlamps were effective in daytime, but most effective in overcast conditions. Rear light enhancements were unsuccessful, although dual amber lights at front or rear were of tangible effect.

COLEMAN, B. (1975). Time to update the sidecar? *New Scientist* 1975-04(66) 945, pp. 136-7.

- emphasises 'the very high skid resistance of the motorcycle combination and the safety and cheapness reflected by the low insurance premiums'.

COVINGTON, J.P. (1973). Safer designs urged for motorcycles and recreational vehicles. *Automat. Engng* 1973-09(81) 9, pp. 49-55.

- a summary coverage of issues raised at the U.S. National Motor Vehicle Safety Advisory Council of the U.S. DOT of an annual congress devoted to these vehicles.

ERIKSSON, L.J. (1974). Design considerations for motorcycle exhaust systems. SAE 740626, 6 pp.

- discusses the severe constraints that motorcycles place on these parameters due to their small size and high performance requirements.

HORBERG, U. and RUMAR, K. (1975). Running lights, conspicuity, and glare. Department of Psychology, University of Uppsala, Sweden.

- motorcycles with headlamps on in daylight were conspicuous as cars with no lights and viewed head on; and subjects who knew where to look could detect any vehicle up to the experimental limit of 1500 m.

JANOFF, M.S., CASSEL, A., FETNER, K.S. and SMIERCIAK, E.S. (1970). Daytime motorcycle headlight and tail light operation. U.S. Dept. of Transport Report DOT HS-800-321. Washington, U.S.A. (Franklin Institute Res. Lab. R & D Report 1970-08. No. F-C2588) 190 pp.

———— and CASSEL, A. (1971). Effect of distance and motorcycle headlight condition on motorcycle noticeability. *Highw. Res. Rec.* 372, pp. 64-68.

- results of comparative experiments at distances from 50' to 300' in Philadelphia: headlight usage significantly increased noticeability.

JAPANESE STANDARDS ASSOCIATION (1970). Lighting and signalling equipment for automobiles. JIS D 5500, 20 pp.

- includes motorcycle equipment.

JENNINGS, G. (1974). A study of motorcycle suspension damping characteristics. SAE 740628, 10 pp.

- quantifies the match between subjective rider appraisal and reproducible testing procedures for this critical suspension component.

KNIGHT, R.E. and PETERSON, H.C. (1971). Dynamics of motorcycle impact. Vol. III Digital computer simulation of two dimensional motion of motorcycle and dummy rider. Denver Research Institute Report DR1 2574, 129 pp.

- a two dimensional crash simulation program in FORTRAN is given, and an ALGOL CALCOMP plotter program for visual display of crash sequences also provided: the programs were developed as part of a crash test program.

MIENERT, R.J. (1974). Antilock brake system application to a motorcycle front wheel. SAE No. 740630, 7 pp.

- a range of systems were tried, and the fluid powered system adopted for use with a standard caliper has exceeded expectations on test in the field.

NEWMAN, J.A. and WEBSTER, G.D. (1974). The mechanics of motorcycle accidents. Am. Assn Auto. Medicine. Proc. 18, 38 pp.

- 1:32 scale models used to assist tracing linematic behaviour of vehicles and accidents, based on accidents in Ottawa during the summer of 1973.

NORDIC SAFETY COUNCIL (1975). Motorcycle and moped safety and construction. Report 13, 201 pp. Stockholm.

ROBERTSON, L.G. (1975). Motorcycle helmet and daytime headlamp use laws: effects on use and fatalities. Insurance Institute for Highway Safety. Washington.

- a slight, but not statistically significant, reduction in accidents - but a significant decrease in fatalities.



SHARP, R.S. (1971). The stability and control of motorcycles. *J. Mech. Eng. Sci.* 13(5), pp. 316-329.

- mathematical models are developed which include driver, rider, and three alternative assumptions about tyre behaviour.

TIEDEMANN, J.B. (1973). A stowable urban vehicle. Am. Soc. Mech. Eng. R & D Report ASME 73-1C, 4 pp.

- improvement of a folding motor-scooter design for urban use.

U.S. DEPARTMENT OF TRANSPORTATION (1975*a*). Acceleration and passing ability: a comparison of acceleration and passing ability for 1975 passenger cars and motorcycles. Consumer Aid Series 1975-01 5(3), 58 pp.

- a regularly updated document.

———— (1975*b*). A comparison of braking performance for 1975 passenger cars and motorcycles. Consumer Aid Series 1975-01 5(1), 40 pp.

- based on 60 mph and skilled drivers under controlled conditions.

WESTCOTT, J.S. (1975). Safety motorcycle. Proc. Inst. Mech. Eng. 189(1), 16 pp.

- use of a 24" scale model plus dummy for physical collision analysis simulation.

WILKINS, H.A. (1969). The cost and benefit of antilocking brakes on motorcycles. TRRL Report LR261. Crowthorne.

- based on full-flow MAXARET experiments, and now superseded at TRRL by the more suitable Mullard electronic antilock caliper system with its integral pump.

WILLIAMS, M.J. (1976). The importance of motorcycle visibility in accident causation. ARRB/ADOT Symposium: Motorcycles and Safety. June. Australian Road Research Board. pp. 59-94.

- based on 1508 accidents in Victoria during 1974, drawn from police files. 16.2 per cent of all accidents occurred when another road user moved into motorcycle path as he 'did not see' the oncoming machine. 65 per cent were during daylight, 27 per cent at night, 8 per cent at dusk/dawn. A detailed breakdown is given by a code of motorcycle movements.

WOLTMAN, H.L. (1974). Some day and night visual aspects of motorcycle safety. *Trans. Res. Rec.* 502, pp. 1-8.

- daylight visibility of two fluorescent and four conventional pigments: night visibility cues and perceptual models of visual comprehension are considered in terms of motorcycles.

## 7. MOTORCYCLES IN A TRANSPORT PLANNING CONTEXT

ANON (1973). Private passenger transport entering Central London. July, 1973. London Transport Planning Note 47, 4 pp.

- motorcycle and bicycle use had risen, against a background of little change in car trips.

BUCKLES, P.A. (1973). Journey times by bus and car in Central London in 1972. *Traff. Engng Control.*

- compares 1963 to 1972 journey speeds: motorcycles were found to be the fastest mode of transport (13.2 mph in 1972 v 11.2 mph for cars in 1972).

HEERE, E. (1972). Traffic in Assen. Verkeerstechnik. Netherlands. 23(11), pp. 508-515.

- Assen has 36,000 inhabitants: motorcycle and pedal-cycle trips are distinguished.

RICHARDS, M.G. and BEN-AKIVA, M.F. (1975). A disaggregate travel demand model. Saxon House, Farnborough, U.K. 163 pp.

- mode choice in Holland emphasises the major role played by mopeds.

WIGAN, M.R. (1976). User issues in motorcycle safety. ARRB/ADOT Symposium: Motorcycles and Safety. June. Australian Road Research Board. pp. 95-118.

- an analysis of economic, planning, safety, usage, design, training and legislative factors from a user and a policy viewpoint.

## 8. MOTORCYCLE TRAUMA

ANON (1969). An evaluation of motor vehicle accidents involving motorcycles - severity, characteristics, effects of safety regulations. State of New York, Department of Motor Vehicles, Division of Research and Development. R & D Report 1969-12, 58 pp.

- sequential data from 1961-68. 5 per cent of registered motorcycles were involved in accidents, 95 per cent gave rise to injuries. Effects of safety propaganda and intensified enforcement had a detectable effect. Passengers suffer a 20 per cent greater chance of death than drivers. Trauma propensities are: legs in 58 per cent of accidents: trunk - 29 per cent: arms - 27 per cent and head - 18 per cent. 80 per cent of vehicles involved in these analyses were new.



DRYSDALE, W.F., KRAUS, J.F., FRANTI, C.E. and RIGGINS, R.S. (1975). Injury patterns in motorcycle collisions. *J. of Trauma* 15(2), pp. 99-115.

- a comprehensive analysis of data collected in Sacramento County, California, U.S.A. in 1970: using 1273 cases of confirmed medical treatment of motorcycle injuries. Only 39 per cent were identified in official police statistics. Annual injury incidence of 2 per cent per 1000 population with a peak at 18 for male drivers. 4 per cent of all registered motorcycles were involved in injury accidents in the year and 45 per cent of injuries were serious. The average hospital stay was 12 days. Detailed distributions of single and multiple trauma are given.

GRATTAN, E. and CLEGG, N.G. (1973). Clinical causes of death in different categories of road user. International Conference on the bio-kinetics of impact. IRCOBI Proceedings Amsterdam, 1973, pp. 73-82.

- injury to head and to chest equally common for motorcyclists in this sample of 289 fatal accidents.

HIGHT, D.V., SIEGEL, A.W. and NAHUM, A.M. (1973). Injury mechanisms in motorcycle collisions. Proc. 17th Conf. of Am. Assn for Automotive Medicine, Oklahoma. October, 1973, pp. 166-192.

- Southern California data: injury patterns are discussed with collision kinematrics, and recommendations made for injury reduction by motorcycle modification.

JAMIESON, K.G. and KELLY, D. (1973). Traffic injuries in Brisbane hospitals over one decade. Queensland Department of Transport, Brisbane.

## 9. MOTORCYCLE DRIVER LICENCING

NATHAN, L.B.G. (1974). State procedures for the licencing of motorcycle operators. Highway Safety Research Center, University of North Carolina. R & D Report 1974-06, 67 pp.

- questionnaire results from 50 U.S. States on licencing procedures. Age, medical, vehicle, testing, and procedural factors are listed with provision of information to motorcyclists and off road trail usage.

NATIONAL HIGHWAY TRAFFIC ADMINISTRATION (1975). Motorcycle driver licencing and training program. MATA. 2 pp.

- uses the Motorcycle Safety Foundation tests for California's Department of Motor Vehicles to carry out a 2-3 year monitoring program of the effects.

SMITH, D.I. (1976). Evaluation of the graded motorcycle licence scheme in Western Australia. ARRB/ADOT Symposium: Motorcycles and Safety. June. Australian Road Research Board. pp. 119-143.

- a graded licence scheme was introduced in 1973: before and after groups were in excess of 2500 subjects. No significant change in any accident factor could be found. The graded licence system in question merely linked a test on a given size of machine to its use, and therefore covered only the skill factors related to physical size and performance, and not the questions of experience on small machines before large.

## 10. MOTORCYCLE AIR POLLUTION FACTORS

HARE, C.T. (1972). Small engine emissions and their impact. SAE Journal, 1972-80(7), pp. 15-25, 55.

- covers both 2-and 4-stroke motorcycle motors and discusses tests and emissions for both.

WECHEM, C.L. Van (1974). Investigation of the emission of small 2-stroke motorcycle engines. Interim Report 1974-05. Institute for Road Vehicles TNO, Delft.

- special emphasis on 2-stroke motors to reduce CO and hydro-carbon emissions.

## 11. MOTORCYCLE TRAINING

HARTMAN, C.H. (1974). Motorcycle operator task analysis research. Am. Assn Auto. Medicine. pp. 440-444.

HOME OFFICE. (1973). Motorcycle roadcraft. The police motorcyclists' manual. London, HMSO. 72 pp.

JAMES, R.S., BERENYI, J.S. and STRANG, P.M. (1976). Approaches to training suggested by a questionnaire survey of motorcyclists. ARRB/ADOT Symposium: Motorcycles and Safety. June. Australian Road Research Board. pp. 144-156.

- a postal survey of 3198 new riders carried out through 1975 in Victoria. 48 per cent had ridden over 1000 miles before obtaining a learners permit, but still 85 per cent felt that driver training would reduce accidents. Only 23 per cent had had riding experience in heavy or medium traffic before learners permit.

JINGU, J. and GATELY, D. (1967). Common sense tips for safe sportscycling. Yamaha International Corporation, Montebello, California, U.S.A.

- an extensive and detailed training document for general issue.



McKNIGHT, J. and HEYWOOD, H.B. (1974). Motorcycle task analysis. Motorcycle Safety Foundation, Linthicum, Maryland, U.S.A. R & D Report 1974.

- a comprehensive specification of the behaviour, knowledge and skills required for safe operation of motorcycles.

MOTORCYCLE SAFETY FOUNDATION (1974). Instructional objectives for Motorcycle safety education. 1974-11. 45 pp.

- objectives are set out for organising or evaluating a program for motorcycle safety.

MUNRO, S. (1974). The development of a national motorcycle training program. Am. Assn Auto. Medicine, Proc. Vol. 18, 11 pp.

- the development of the Canadian National Motorcycle training program (Canada Safety Council) is described. A review of accident causal literature is given; and training and education are highlighted as cost effective counter-measures.

RAYMOND, S. and TATUM, S. (1973). An evaluation of the RAC/ACU training scheme, first report: An evaluation of the effectiveness of the RAC/ACU motorcycle training scheme - an interim report. Salford University, Road Safety Research Unit. Salford, U.K. 190 pp.

SUZUKI, T. (1973). System, curricular and effects of safe driving education program for young motorcyclists. Proc. 1st International Conf. on Driver Behaviour. Zurich. October, 1973. Pub. Honda, Tokyo.

- a report on 2½ year's experience of a high school training program for 16-18 year olds. Statistical data are included.

YOUNG, M.E. (1975). Driver education. NTIS/PS-75/114/6ST. Springfield, Virginia, U.S. 114 pp.

- a bibliography containing 109 abstracts including motorcycles.

## 12. MOTORCYCLE HELMETS

AUSTRALIAN STANDARDS ASSOCIATION (1974). Protective helmets for vehicle users. AS 1698-1974.

GILLIES, N. (1976). Performance of crash hats in New South Wales. ARRB/ADOT Symposium: Motorcycles and Safety. June. Australian Road Research Board. pp. 180-207.

- the basis for ADR1698-1974 is reviewed and details of the test method given. Energy test results for a range of helmets on sale in N.S.W. from 1971-76 are given, with a comparison between manufacturers claims and test results.

JEHU, V.J. (1971). Swingaway test apparatus. Road Research Laboratory Report No. LR407.

- basis of temporal protection test for 1972 issue of BS2001.

RICHARDSON, H.A. (1974). A motorcycle safety helmet study. U.S. Dept. of Transportation, Report DOT/HS-861 137.

- comparison in U.S. States: Illinois had 3 per cent fatals of Michigan, where helmet usage was then compulsory.

RYAN, G.A. (1967). Injuries in traffic accidents. *New England J. Med.* 276, 19, pp. 1070-1076.

- crash helmets did not reduce injuries as much as expected. 59 per cent of helmet users and 69 per cent of non-users received nil or minor injury. The sample was biased by drawing only on ambulance call records, in which 96 per cent of riders were found to be injured.

SCALONE, A. and DAMIS, R. (1972). Verification of procedures for rule-making - motorcycle headgear. U.S. Dept. of Transportation, Report DOT/HS-800-752.

- results of 132 helmets tested to FVMSS218. Special need for a good fit for reproducible results.

THURLOW, S.J. (1958). Apparatus for testing protective helmets. Road Research Laboratory Report No. RN/3390/SJT.

- drop towers British Standard method for 1956 and 1960.