

Informal document No. WP.29-148-24  
(148<sup>th</sup> WP.29, 23-26 June 2009,  
agenda item 6)

# **Assessment of Child Helmet Efficacy for Motorcycle Use in Malaysia**

---

# CONTENT

---

- ❑ Regulations
- ❑ Malaysian Accident Data
- ❑ Literature
  - Anthropometric and Bio Mechanical Differences
  - Helmet effectiveness, injury
  - Child Helmet Design
- ❑ Child Helmet Campaign
- ❑ Typical Helmet Wearing at School Malaysia
- ❑ Specification of Child Helmet
- ❑ Child Helmet – Availability and Design
- ❑ Child Helmet Testing
- ❑ Summary
  - Age
  - Helmet Design
- ❑ Challenge/Opportunity

# MOTORCYCLE REGULATIONS

Country	No of Passenger	Passenger Age Limit	Helmet Requirement
Malaysia	Only 1 passenger allowed	No requirement	Yes
Vietnam	No requirement	No requirement	Yes
US,4 states	No requirement	Varies from > 5 to >8 years	Yes
Australia	No requirement	≥8 years, unless in a side car	Yes

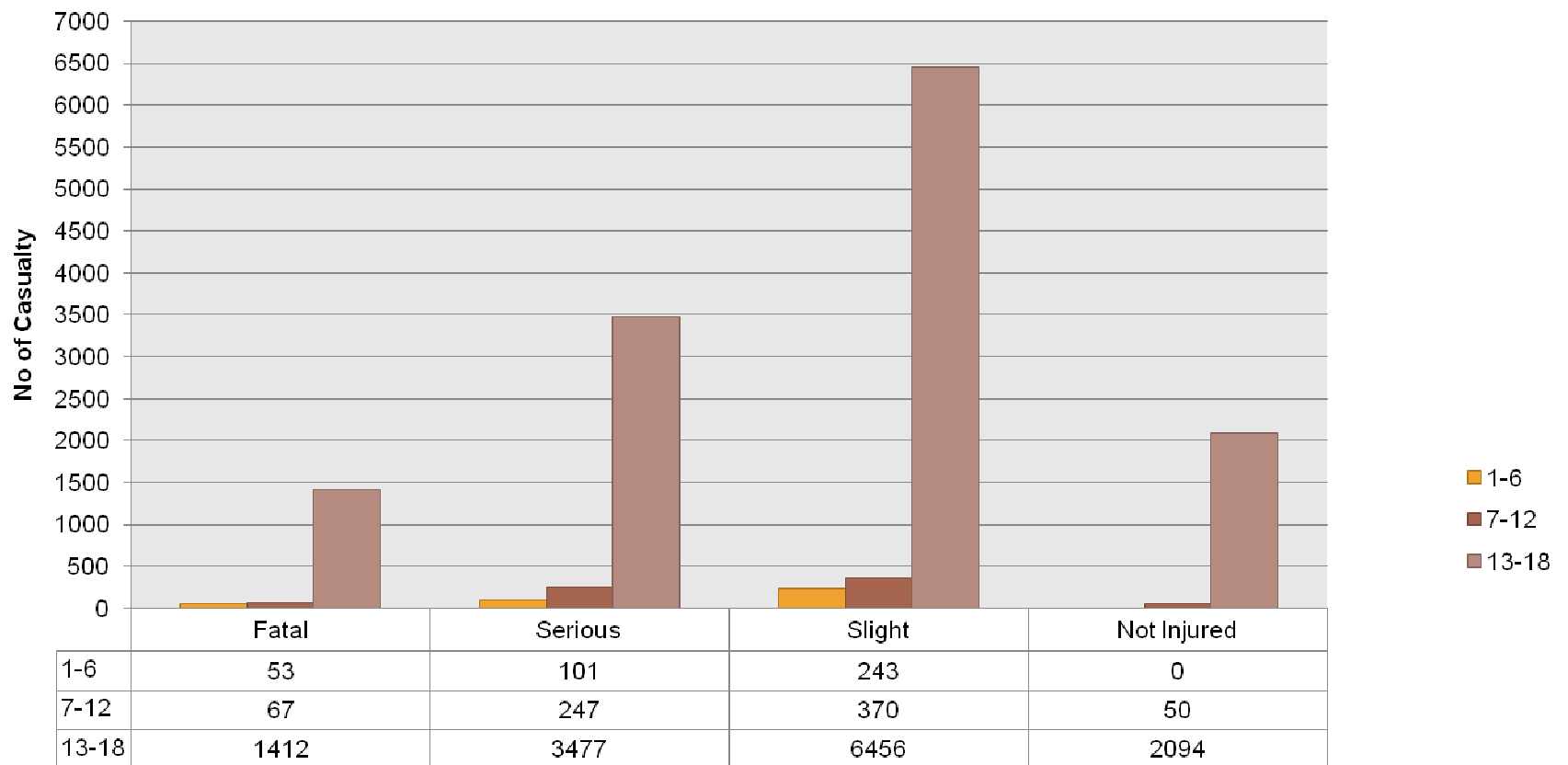
# ACCIDENT DATA (2006-2008) -MALAYSIA

## (Children age 1 to 18 years)

Severity	2006	2007	2008	Mean %
Fatal	485	469	578	511 (10.5)
Serious	1314	1223	1288	1275 (26.3)
Slight	2470	2330	2269	2356 (48.6)
Not Injured	707	628	785	707 (14.6)
<b>Total</b>	<b>4976</b>	<b>4650</b>	<b>4920</b>	<b>4849</b>

**Average Annual Motorcycle fatality in Malaysia 3600,  
Child fatality in Motorcycle Accidents > 14 % annually**

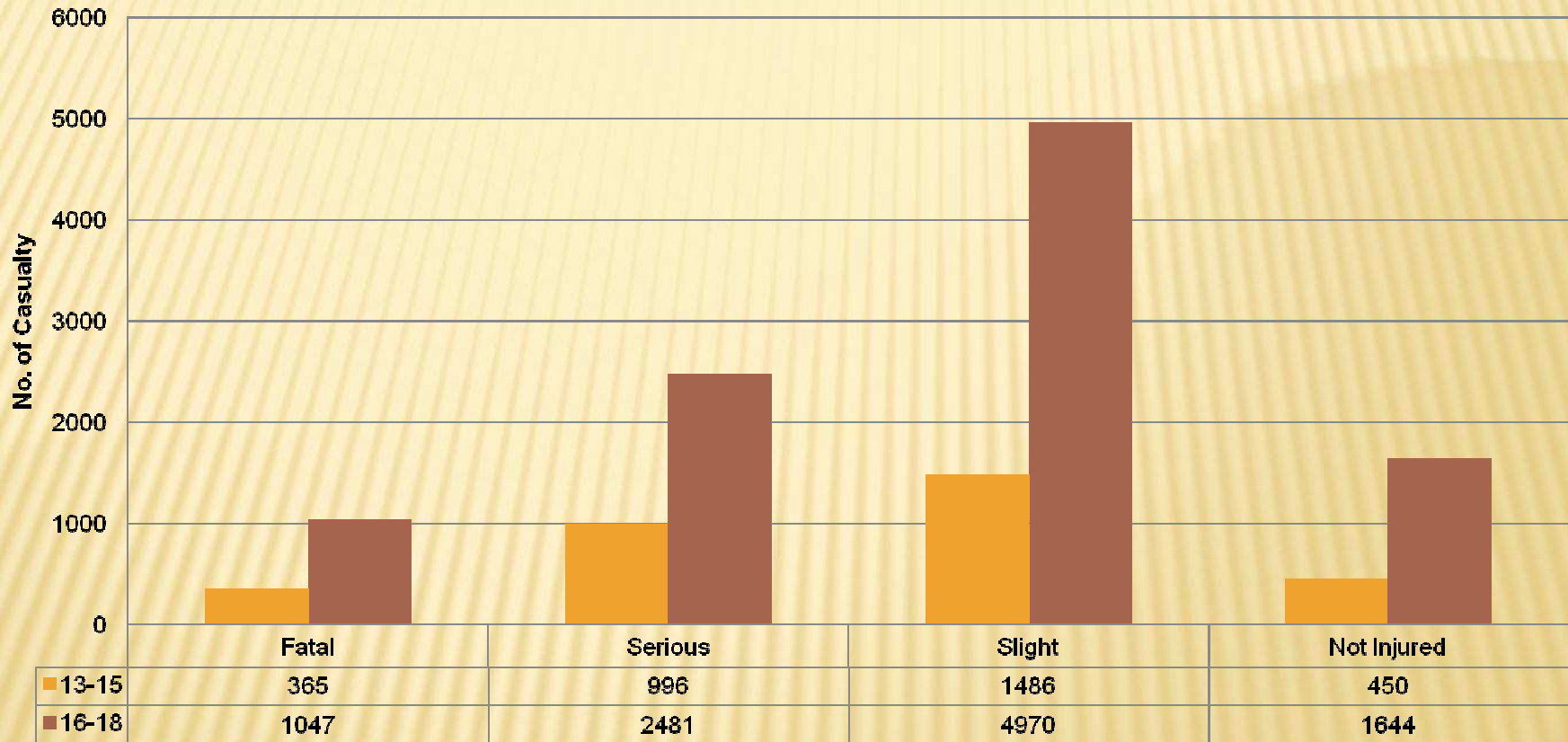
# CASUALTY BY CHILDREN AGE GROUP



**Age 1-6 years fatality 3.5%, Age 7-12 years fatality 4.4%**  
**For 1-12 age**

# CASUALTY FOR AGE GROUP 13 TO 18 YEARS

Casualty for Age 13 to 18 years



**Licensing Age starts at age 16 years**

# LITERATURE REVIEW

---

1. Helmet effectiveness in reducing risk of injury and fatality widely researched - Moskal A, Deutermann, W., Dee., Liu B., et al.
2. Sub standard helmet provides inferior protection to user – Asa C.P., et al.
3. Malaysian helmet use rate 60~67% - Kulanthayan S., et al.
4. Applicable Legislation plus appropriate enforcement proven to increase use of helmet , absence or low enforcement resulted in low helmet use – Hung DV, et al.
5. RTA in schoolchildren due to lack in supervision and enforcement activities – Kanchan et al, Rohana et al.

## LITERATURE REVIEW

---

6. Low child helmet use due to fear of neck injury – WHO report in Vietnam
7. No significant difference in odds of cervical injury in helmeted and unhelmeted users – Kasantikul et al, Lin et al, Moskal et al, Goslar et al.
8. Most studies were on adult subjects, limited evidence on children injury and motorcycle use
9. Children more susceptible to permanent brain damage than adult when subjected to similar impact forces – Anderson et al



# ANTHROPOMETRIC AND BIO- MECHANICAL DIFFERENCES

---

- × University of Michigan Transportation Research Institute(UMTRI) data-Dr. Kathleen Klinich
  - + Head size growth development(head breadth, depth, circumference)
    - × 0-4 years old → growth rapidly
    - × 4 years old → 90% of adult size
    - × 12 years old →95% of adult size
    - × 20 years old →the bone plates of the skull fully close
  - + Neck Development
    - × 4 years old →75% of adult size
    - × 12 years → 85% of adult size

(Arbogast K, Margulies S, Patlak M, Fennes H, Thomas D. *Review of Pediatric Head and Neck Injury Conference*, Philadelphia, PA, 2003 )

# ANTHROPOMETRIC AND BIO- MECHANICAL DIFFERENCES

---

- ✘ Mr Edward Becker (Snell Memorial Foundation)
  - + Facial structure of children is vastly different from the adults
  - + Children heads are smaller in vertical height
- ✘ Dr. Susan Margulies (University of Pennsylvania)
  - + The greater water content in a child's brain makes it stiffer than an adult
  - + The skull stiffness increase by age

(Arbogast K, Margulies S, Patlak M, Fennes H, Thomas D. *Review of Pediatric Head and Neck Injury Conference*, Philadelphia, PA, 2003 )

# ANTHROPOMETRIC AND BIO- MECHANICAL DIFFERENCES

---

- ✘ Dr. Kristy Arbogast(The children's Hospital of Philadelphia)
  - + Neck muscles of children are weaker than adult-neck ligaments, it can stretch more
  - + Children bend their neck at higher vertebral level
  - + Their vertebral joint are flatten so they don't restrict much vertebral motion

(Arbogast K, Margulies S, Patlak M, Fennes H, Thomas D. *Review of Pediatric Head and Neck Injury Conference*, Philadelphia, PA, 2003 )

# ANTHROPOMETRIC AND BIO- MECHANICAL DIFFERENCES

---

- ✘ Scaling helmet weight by using animal study by Randall Ching( University of Washington Applied Mechanic Laboratory)

## Assumption

- + Accept maximum helmet weight for adults is 2 kg (Prange,2003)
- + Scaling based on functional metric(stiffness, modulus, range of motion)

(Arbogast K, Margulies S, Patlak M, Fennes H, Thomas D. *Review of Pediatric Head and Neck Injury Conference*, Philadelphia, PA, 2003 )

# CHILD HELMET MASS SCALE

Age Group (Years)	UW (Baboon)			MCW (Goat) (Hiker, 2002)		Mean (± IS.D.)
	Tension	Compression	Bending	Tension	Bending	
	1	0.42	0.29	0.19	0.17	0.11
3	0.47	0.38	0.28	0.23	0.15	0.30 (±.13)
6	0.56	0.51	0.41	0.54	0.57	0.52(±.06)
12	0.71	0.72	0.64	0.85	0.62	0.71 (±.09)
Adult	1.0	1.0	1.0	1.0	1.0	1.0

Age Group (years)	Lower Limit (kg)	Higher Limit (kg)
1	0.23	0.72
3	0.35	0.86
6	0.91	1.17
12	1.24	1.6
Adult	-	-

Arbogast K, Margulies S,  
Patlak M, Fennes H, Thomas  
D. *Review of Pediatric Head  
and Neck Injury Conference*,  
Philadelphia, PA, 2003

# ANTHROPOMETRIC AND BIO- MECHANICAL DIFFERENCES - SUMMARY

## Summary of findings

- ✘ The Anthropometric and Bio-mechanical of child and adults are different
- ✘ Adults helmet may not be suitable for child of early age (<12 years old)
- ✘ There is a need to develop helmet to cater children of various age
- ✘ Minimum age limit of the motorcycle passenger (pillion) need to be established

# TYPICAL CHILD HELMET DESIGN REQUIREMENTS

---

- × Size(cm) - 50 – 57
- × Outer Shell Thickness(mm) – 5
- × Inner Shell Thickness(mm) -25
- × Mass(g) – 500 – 1000
- × Impact test performance – less than 200 g

(Patent Appl. No. : full reference MY PI 20031295)

# CHILD HELMET CAMPAIGN MALAYSIAN EFFORT

---

## Direct

- Paper media
- Soft media, i.e. [www.panducermat.gov.my](http://www.panducermat.gov.my)
- Advertisement and TV commercials

## Indirect

- Addressing children to wear helmets
- Instill safety habit from young age, carry over  
to adulthood



# CHILD HELMET CAMPAIGN MALAYSIAN EFFORT

Advertisement and TV commercials



# CHILD HELMET CAMPAIGN MALAYSIAN EFFORT

Advertisement and TV commercials



# CHILD HELMET CAMPAIGN MALAYSIAN EFFORT

## Advertisement and TV commercials



# CHILD HELMET CAMPAIGN MALAYSIAN EFFORT

## TV News



# CHILD HELMET CAMPAIGN MALAYSIAN EFFORT

## Poster



**Topi keledar  
kanak-kanak  
bukan aksesori.  
Ianya satu keperluan.**

  
Lindungi Anak Anda Dengan Topi Keledar Kanak-Kanak.  
Anda Mampu Mengubahnya.



**Tiada gunanya  
kalau tidak  
diikat ketat.**

  
Ikat Topi Keledar Anda. Anda Mampu Mengubahnya.



**Lindungi diri anda  
dengan topi keledar yang  
disahkan oleh SIRIM.  
Bagaimana?**

Mudah sahaja, pastikan adanya pelekat pengesahan SIRIM. Dengan ini, anda dapat mengesahkan topi keledar muda yang telah diuji untuk menyerap impak dan memberikan perlindungan menyeluruh jika berlaku kemalangan. Kemalangan berlaku tanpa diduga, jadi kenapa ambil risiko?

   
Anda Mampu Mengubahnya.

# TYPICAL CHILDREN HELMET WEARING IN MALAYSIAN SCHOOLS -KLANG VALLEY

	Use of Helmet			
	Yes	Percentage , %	No	Percentage, %
Urban (N=309)	79	28.6	230	74.4
Suburban (N=493)	197	40.0	296	60.0

# SUBURB SCHOOLS

School	Use		Not Use
	Standard	Non Standard	
Sek. Keb. Jln Semenyih Dua Kajang	39.7	25.0	35.3
Sek. Keb. Taman Jasmin Dua Kajang	25.5	12.7	61.8
Sek. Keb. Seksyen 7 Bangi	16.4	20.0	63.6
Sek. Keb. Bandar Tun Hussein Onn (2)	34.9	8.4	56.6
Sek. Keb. Dato Abu Bakar Baginda Sepang	14.3	5.4	80.4
Sek. Keb. Puchong Batu 14	4.6	4.6	90.8
Sek Keb Taman Cuepacs Bt 9 Cheras	28.4	23.9	47.7
Sek Keb Taming Jaya, S.Kembangan	34.8	21.7	43.5
Percentage, %	<b>25.0</b>	<b>15.0</b>	<b>60.0</b>

# URBAN SCHOOLS

School	Use		Not Use
	Standard	Non Standard	
Sek. Keb. Padang Jawa Petaling, Shah Alam	3.2	1.1	95.7
Sek. Keb. Taman Sri Muda (2) Jln Cermat 25/36 S.Alam	26.8	14.3	58.9
Sek. Keb. Bukit Kuda Jln Landasan Klang	21.0	5.3	73.7
Sek. Keb. Seafield 3 Pesiaran Kewajipan 47610 USJ Subang Jaya	12.4	18.8	68.8
Sek. Keb. Seafield Jln USJ 6/3 Subang Jaya	0	23.1	76.9
Sek. Keb. Kg Lindungan Jln PJS 10/11 Petaling Jaya	16.0	12.0	72.0
Sek. Keb. Bandar sunway Jln PJS 7/15 Petaling Jaya	20.7	5.8	73.5
Sek. Keb Klang Jln Dato' Hamzah Klang	27.8	22.2	50.0
<b>Percentage, %</b>	<b>15.2</b>	<b>10.4</b>	<b>74.4</b>



# CHILDREN AT RISK



# CHILDREN AT RISK



# CHILDREN AT RISK



Cannot hold  
parents tightly

The legs are  
dangling on  
the air



# CHILDREN AT RISK



Children sitting  
in front of rider

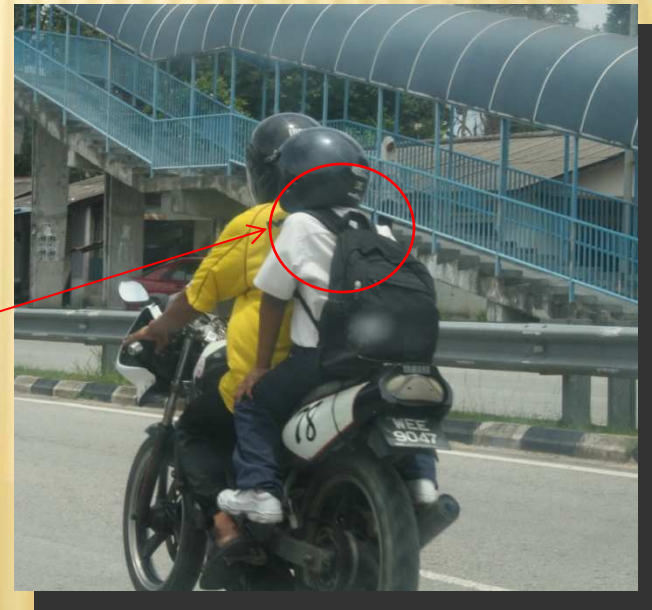


# CHILDREN AT RISK-HELMET



Helmets are not design to children size

Helmet size on the vertical are big until it's rest on the shoulder



## SUMMARY-HELMET USE STUDY

- ✘ Focusing on school areas where motorcycles are one of the popular mode of transport
- ✘ The findings
  - + Majority of the children are not wearing helmets
  - + There are cases more than 1 pillion passenger carried on the motorcycles
  - + There are cases where the physical size of the children may not be suitable to become pillion passengers (refer to photo)
  - + Some helmet size may not be suitable to the children head size especially on the vertical side

# SUMMARY-HELMET USE STUDY

- × The findings (continue)
  - + Majority of the younger age children (maybe less than 7 years) are carried in front of the rider – safer? Or otherwise?

# CHILD HELMET AVAILABILITY AND DESIGN

- ✘ Standard child helmet (Compliance with MS 1),
  - + Current available CH are mainly fitted for 6 years and above (based on child helmet dimension and head circumference)
  - + The helmet designed with thicker foam in order to fit with child head size. The outer shell is using the same size with adult
- ✘ Non-standard – non compliant to any standards
  - + Available in various size for children
  - + Available in different design(e.g toy, game and others)
  - + The performance is questionable ?



# STANDARD CHILD HELMET



Size 54cm



Approval sticker, behind comfort liner

# TOY/GAME HELMET (NON-STANDARD)



# HELMET SPECIFICATION

---

- ✘ MS1: 1996 Addresses general helmet construction and minimum performance criteria, similar to ECE R22 but without HIC
- ✘ Size available: min 50 ~ max 62 cm of head circumference, size not suitable for age <6 years
- ✘ Current Child helmet test with the same standards with Adult

# HELMET STANDARDS COMPARISON

Standard	Snell/FIA CM2007 Std for Protective Headgear	MS1727:2004 Impact for children	MS1:1996 Spec for Protective Helmet for Road User	Malaysia Patent PI 20031295 Safety Helmet for Children	ECE R22 Std for Helmet and Visors	Vietnam Technical Regulation for Protective Helmets QCVN 2:2008
Scope	Children motorsports use	Motor vehicle free environment, <7 yrs old	Vehicle user	Children	Moped and Motorcycle use	Road users and moped
Size, cm	<49 – 59	50-62 Head form	50 – 62 Headform	45 – 60	50 – 62 Headform	<50, 50-52, >52
Mass,g	1000 – 1300	No requirement	No requirement	500-1000	No requirement	<u>Full face</u> , * L <1500 M& S <1200 <u>Open and ½ shell</u> L <1000 M&S <800
Performance						
Impact test, m/3.8– 7.75		4.57-5.42	5.94-6.42 (1.8 – 2.1m)	5.94-6.42 (MS1:1996)	5.5 – 7.5 (8.5 for oblique test)	4.8 – 6
Max. head deceleration, g	< 290g	<250g	< 300g	<200g	<275	<225g (for <50cm circumference); <300g (for ≥50cm circumference)
HIC value	No requirement	No requirement	No requirement	No requirement	<2400	No requirement
i.Penetration						
drop height, mm	3000	No requirement	2000	No requirement	No requirement	2500
mass of striker, kg	3.0		4.5	No requirement	No requirement	3.0

# STANDARDS COMPARISON SUMMARY

- ✘ Snell covers wider range of sizes
- ✘ MS1, Malaysian Patent and Vietnam specs are lighter in mass, most likely because of Open Face pattern, not Full Face
- ✘ Snell test more severe, probably to cater the rigorous motorsport safety
- ✘ MS1727 and Vietnam standard addresses <50cm size but headform for testing such size is unclear
- ✘ Half shell is accepted in Vietnam standard only

So, further studies may be necessary to correlate children physiology to helmet usage

# CHILD HELMET TESTING

---

In Malaysia,

- ❖ Child helmet – tested to Normal Standard (MS1)
- ❖ Using standard head form prescribed for adult size
- ❖ Specific performance standard for child helmet unavailable
- ❖ Common test parameters, i.e velocity, peak acceleration for child helmet maybe need further research

# TEST PROCESS



Main Test: Impact Energy Attenuation  
Equipment Name: Impact Tester

(Courtesy of SIRIM QAS International )

# TEST PROCESS



Main Test: Resistance to Penetration  
Equipment Name: Penetration Tester

(Courtesy of SIRIM QAS International )



# TEST PROCESS



Main Test: Strength of Retention System  
Equipment : Retention System Test Machine

(Courtesy of SIRIM QAS International )



# CHILD HELMET: IMPACT TEST RESULT

'g' acceleration range	Ambient	Hot	Wet	Ageing	%
<100 g	0	1	1	0	2.3
101-150	9	6	12	9	40.9
151-200	11	4	7	9	35.2
201-250	4	5	4	6	21.6
>250	0	0	0	0	0

# ADULT HELMET: IMPACT TEST RESULT

'g' acceleration range	Ambient	Hot	Wet	Ageing	%
<100 g	0	0	0	0	0
101-150	18	15	16	16	40.6
151-200	16	12	7	16	31.9
201-250	6	13	17	8	27.5
>250	0	0	0	0	0

(Extracted from SIRIM QAS International Test Result)

# CHILD VERSUS ADULT HELMET (IMPACT TEST)

Variable	Child		Adult		Mean Difference	P-Value
	N	Mean (SD)	N	Mean (SD)		
Headform Deceleration, g	8	165.03 (39.985)	160	167.57 (40.791)	2.54	0.63

**No significant relationship**

## COMMENT ON TEST RESULT

---

- ✘ All child helmets passed the impact, penetration and retention system tests, except games helmet which failed the penetration test (may be due to lower shell thickness, not designed for such impact, thus not suitable for motorcycle use)
- ✘ Majority (>70%) of impact values were between 100 - 200 g, none exceeded 250 g (MS1 limit 300 g)
- ✘ Mass of sample child helmet range from 780 – 950 grams
- ✘ Use of common headform for all helmet sizes in impact attenuation test, may possibly provide inaccurate measurement due to fitness issue (over or under, tight/loose)

## CONTINUE

---

- ✘ Requirement of 2 successive impacts at the same spot – 2<sup>nd</sup> impact point was manually determined and may possibly pose some challenge in locating the exact impact point
- ✘ Test sequence – Impact test interchangeably done with penetration test may possibly exhibit a variation in 'g' value

## FINDINGS - AGE

---

- ✘ There are no age limits on the children riding as passenger in Asian countries
- ✘ There are mixed of age limit between US and Australia (range between 5 to 8 years old)
- ✘ Any scientific evidence to support “a” threshold limit for various type of motorcycle (super bike to scooter)
- ✘ There are needs to establish the minimum age limit for children as motorcycle passenger, but at what age?
- ✘ Children anthropometrical constraints must be considered in setting the minimum age requirement – sit properly (Health) and safely(Safety) as rear pillion passenger



# FINDINGS -AGE



Can he sit properly as a rear **pillion passenger**?

As compared to his elder brother?

What Do You Think ?

## SUMMARY – CHILD HELMET

---

- ✘ Children are different in terms of anthropometric and bio –mechanical limit compared to adults
- ✘ A range of helmet to serve different age of children(Children head are growing function of age) is required
- ✘ The weight and size range versus age need to be established and considered in developing children helmet specifications and performance requirements

# CHALLENGES/OPPORTUNITIES

- ✘ Age Limit is required, in view of child safety and health. Thus, a comprehensive scientific study to establish the influence of anthropometric factors and child injury tolerances on injury outcomes of a motorcycle crash is scarce and badly needed.
- ✘ With defined age limit, then only we can determine the more appropriate specification(s) and requirement(s) of a child helmet, with high benefit to cost ratio

## CHALLENGES/OPPORTUNITIES

- ✘ Existing **Adult** helmet standard needs to be enhanced further in addressing child physiological needs
- ✘ Separate **Child** helmet standard with more representative performance criteria or indicator may be required
- ✘ Is there any need to ensure general safety of the helmet as for toy safety, such as CE 88/378/EEC at present, not a concern at all.

# ALTERNATIVE FOR UNDER AGE PASSENGER ?



Child riding belt(Canada)

## Specifications

Belt Weight.....1.5 kgs., (3 lbs)

Shipping Size.....25cm X 25cm X 48cm, (10" X 10" X 19")

Belt Type.....Heavy Nylon

Pad Type.....High Density Foam

Handle Grips.....B.M.X. Style

Solid Nylon Buckles

Pad Cover.....Waterproof Nylon

Child Size.....Maximum 45.5 kgs, (100) pounds



Really Safer  
than not  
buckling up  
??

# ACKNOWLEDGEMENT

---

- ✘ A sincere appreciation to SIRIM QAS International, Malaysia for the full assistance in providing the test facilities and workforce to carry out the experiment, especially to Hj. Suhaimi, Wan Rafi, M.Nasir, and A. Rahman.
- ✘ A special thanks to KS Tan and CL Tan for their effort in high speed filming
- ✘ A special note to Azhar, Yahaya, Ridzuan and Fazli of MIROS for their contribution in making the experiment a success.

---

Thank you

# THE IMPACT TEST

---

- × Video
- × High Speed Video

(With Permission from SIRIM QAS International)



# THE PENETRATION TEST

---

- × Child Helmet with SIRIM Approval
  - + Video
  - + High Speed video
  
- × Toys Helmet
  - + Video
  - + Photo

(With Permission from SIRIM QAS International)

# RETENTION SYSTEM TEST

---

- × Child Helmet with SIRIM Approval

  - + Video

- × Toys Helmet

  - + Video

(With Permission from SIRIM QAS International)