International Federation
of Red Cross and Red Crescent Societies

Shelter Research Unit
an initiative of the **Benelux Red Cross Societies**

CLADDING AND FIXING CONFERENCE

Luxembourg, 3 & 4 of September 2014

Cecilia Braedt (SRU) - Development of Manual on CGI Roofing

CGI Roofing Manual

1. Objective:

To develop a technical resource that can support the Shelter Cluster and shelter actors in the field, to give recommendations and make informed choices about roofing solutions using of CGI.

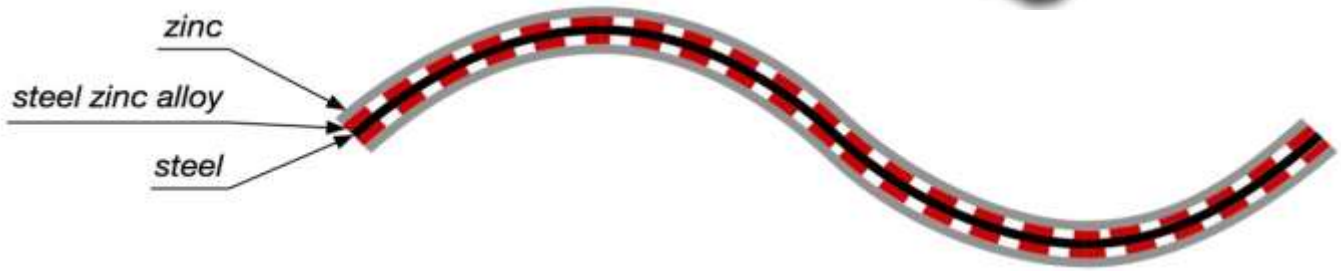
Contents of the Manual

2. Materials

a. **Corrugated galvanized Iron** or steel (CGI) sheets,

- general **specifications**

- The most common **coatings**



2. Materials

- **Durability/service life:** The performance of galvanized steel exposed to open air depends on five main factors: Temperature, Humidity, Rainfall, Sulfur dioxide concentration in the air (pollution)and Air salinity

→ Example usign the online "Zinc Coating Life Predictor" (ZCLP): for a **service life of 10 years**, in Tacloban region (Philippines), the zinc coating should be:

15.2 µm thick in a rural area (107 g/m^2)
20 µm thick in a urban area (140 g/m^2)
26 µm thick in a coastal area (181 g/m^2)

→ 250 g/m^2 zinc coating (recommended by IFRC) corresponds to app. 13.8 years service life in coastal area

2. Materials

b. Support

- Coconut lumber and pine as reference;

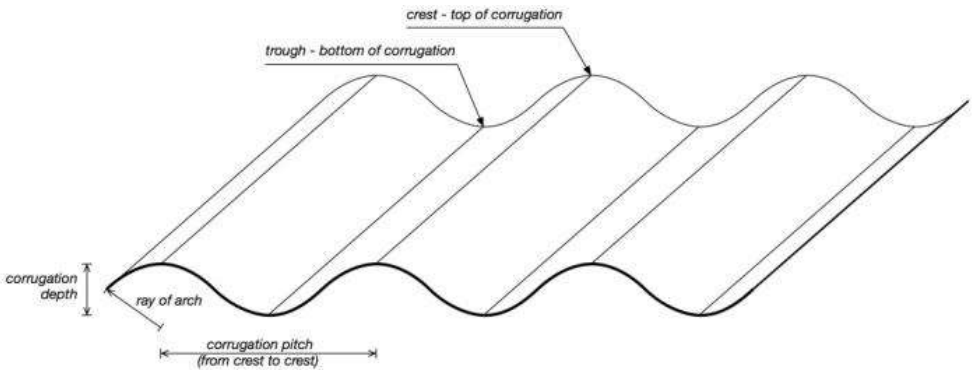
  basic info for bamboo and metal

- fixings, hurricane straps and accessories

3. Material Quality Control (CGI)

a. storage, transportation and safety measures

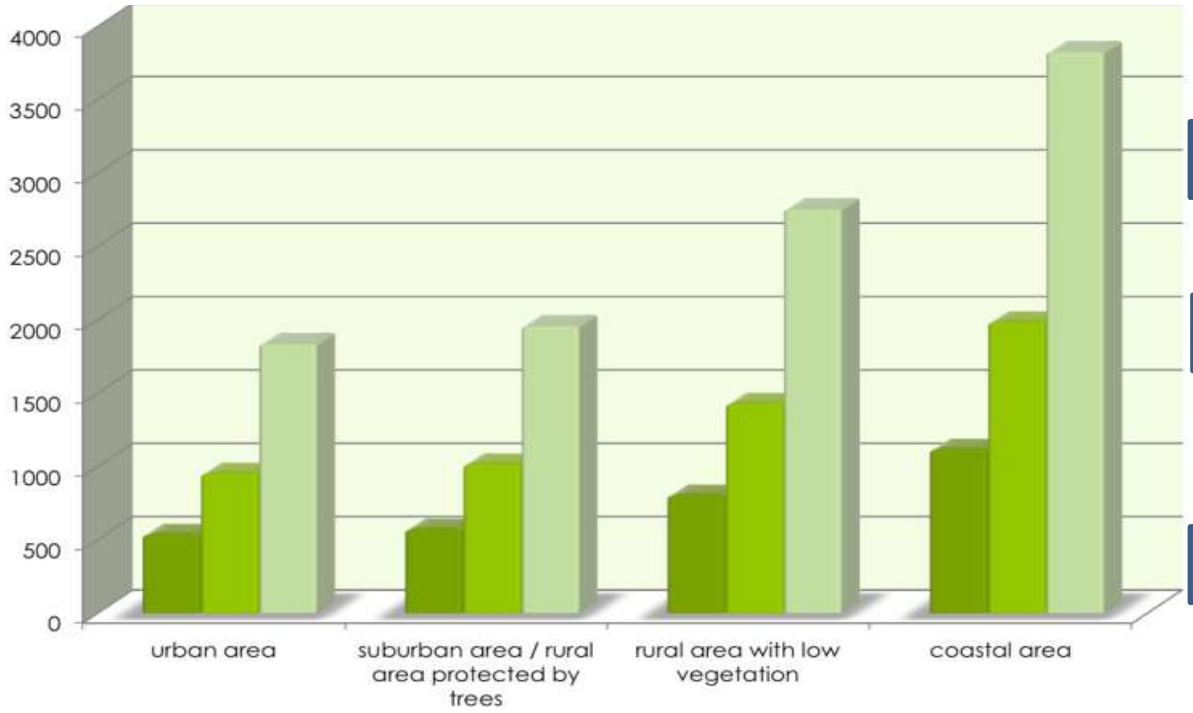
b. How to verify the specs



c. Devices to check the quality of galvanized steel. E.g. “zinc coating gauge” - can measure the thickness of the zinc coating (cost app. 500€)

2. Effects of Wind

Peak velocity pressure (in N/m2) in function of wind speed and exposure situation

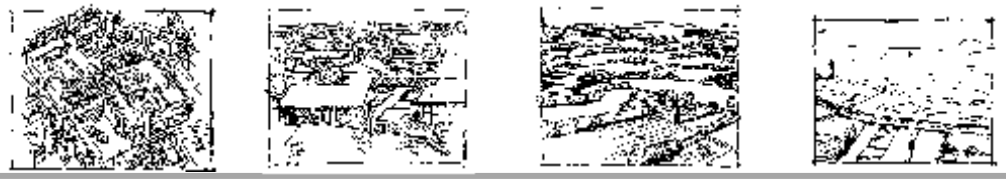


windspeed :

Tropical Storm Cat 1: <100km/h-150km/h

Tropical Storm/Hurricane Cat 2-3(major): 150km/h-208km/h

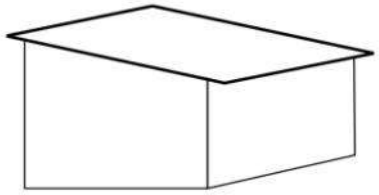
Hurricane Cat 4 (major): 209km/h-251km/h



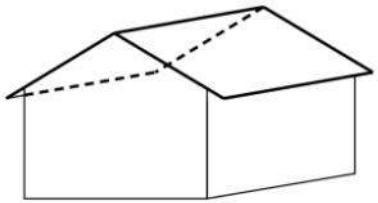
exposure situations

5. Roof Shapes and Pitches

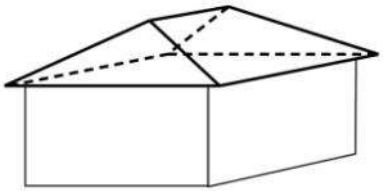
a. Roof shapes



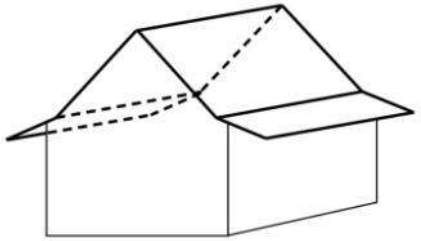
Shed roof / single-pitch roof / monopitch roof



Gable roof / pitched roof / duopitch roof

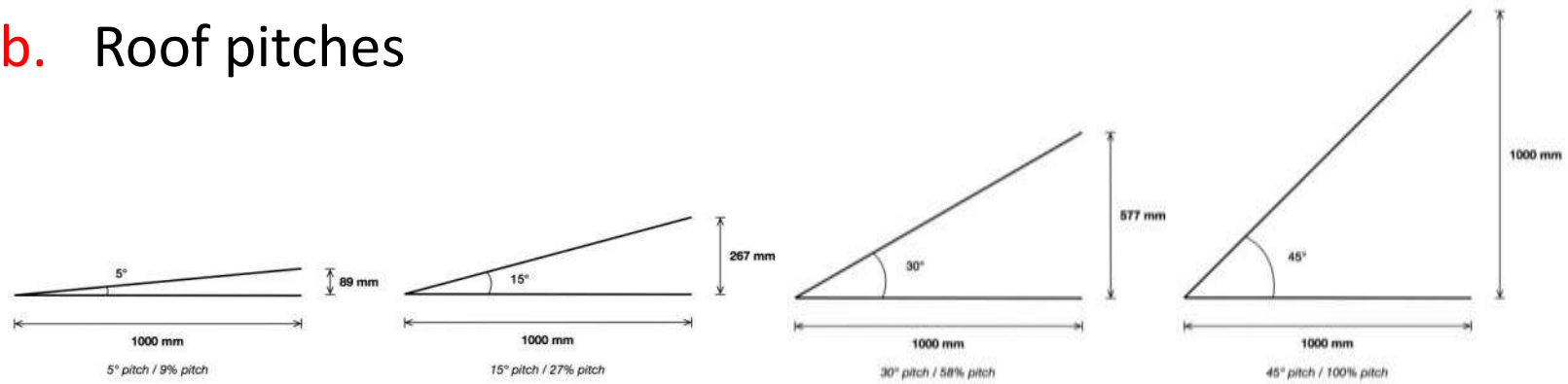


Hip-roof / hipped roof



Gambrel roof

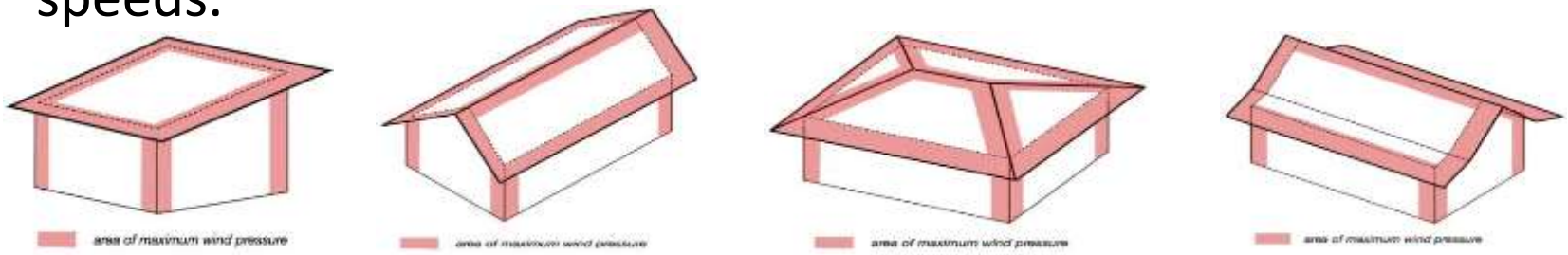
b. Roof pitches



6. Case Study calculations

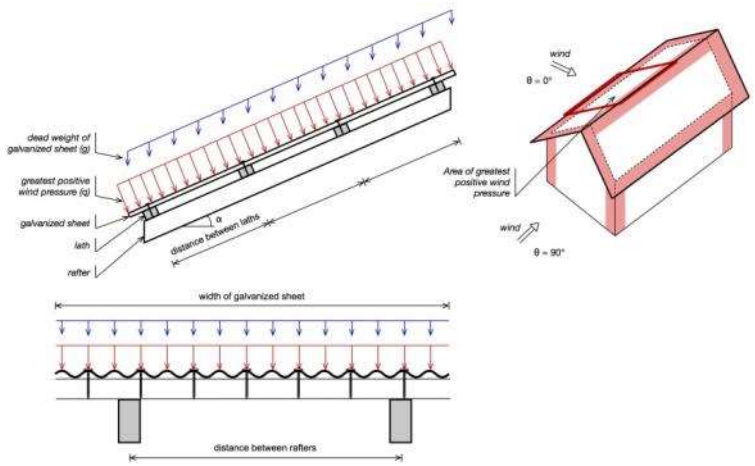
a. Windoad calculations based on a generic 3x6m shelter with
   - CGI roof
   - 45cm eaves
   - Roof structure 45x70mm laths/battens,
   - CGI sheets as of EIC specs (width 914 mm, 11 corrugations, 76.2 mm between corrugations)
   - Roofing nails: twisted shank, length: 63 m

→ Calculations for four roof shapes, each shape with the four pitches, in the four exposure scenarios and for three wind-speeds.



6. Case Study example

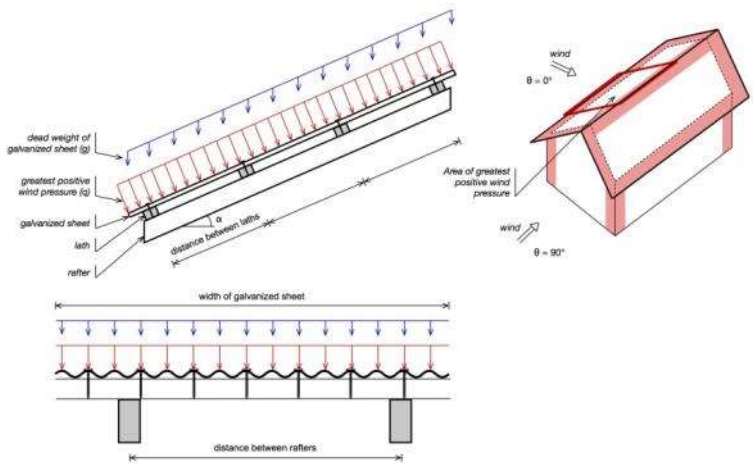
- hipped roof, **pitch = 5 °**
- Basic wind velocity < 150 km/h (cat.1) with peak wind velocity at 208 km/h
- coastal area exposed to the open sea
- distance between laths = 0,60 m (2ft)
- distance between rafters = 1,20 m (4ft)



exposure situation	Peak velocity pressure qp (N/m2)	Corrugated galvanized sheet	Fixings main part	Fixings eaves overhang / hip / ridge	Type of hurricane straps connection between lath and rafter	Type of hurricane straps connection between rafter and top plate
Cat 0 (coastal area)	**1985**	Minimum thickness = 0,40 mm (gauge 30)	2 roofing nails per lath per CGS (penetration length = 45 mm)	**6 roofing nails per lath per CGS** (penetration length = 45 mm)	Maximum support reaction = 5827 (1307 lb) → possible choice: CS18	**Necessity to reduce the distance between rafters (0,90 m)** → Maximum support reaction = 5449 N (1222 lb) + Maximum horizontal support reaction = 270 N (61 lb) → possible choice: H14
Cat II (rural)	1429	Minimum thickness = 0,40 mm (gauge 30)	2 roofing nails per lath per CGS (penetration length = 45 mm)	4 roofing nails per lath per CGS (penetration length = 45 mm)	Maximum support reaction = 5594 N (1254 lb) → possible choice: CS18	Maximum support reaction = 5231 N (1173 lb) + Maximum horizontal support reaction = 259 N (58 lb) → possible choice: H14
Cat III (sub-urban)	1016	Minimum thickness = 0,40 mm (gauge 30)	1 roofing nails per lath per CGS (penetration length = 45 mm)	3 roofing nails per lath per CGS (penetration length = 45 mm)	Maximum support reaction = 3978 N (892 lb) → possible choice: CS20	Maximum support reaction = 3720 N (834 lb) + Maximum horizontal support reaction = 184 N (41 lb) → possible choice: 2x H3 or H10A
Cat IV (urban)	953	Minimum thickness = 0,40 mm (gauge 30)	1 roofing nails per lath per CGS (penetration length = 45 mm)	**3 roofing nails per lath per CGS** (penetration length = 45 mm)	Maximum support reaction = 3729 N (836 lb) → possible choice: CS22	Maximum support reaction = 3488 N (782 lb) + Maximum horizontal support reaction = 173 N (39 lb) → possible choice: 2x H3 or H10A

6. Case Study example

- hipped roof, **pitch = 30°**
- Basic wind velocity < 150 km/h (cat.1) with peak wind velocity at 208 km/h
- coastal area exposed to the open sea
- distance between laths = 0,60 m (2ft)
- distance between rafters = 1,2 m (4ft)



exposure situation	Peak velocity pressure qp (N/m2)	Corrugated galvanized sheet	Fixings main part	Fixings eaves overhang / hip / ridge	Type of hurricane straps connection between lath and rafter	Type of hurricane straps connection between rafter and top plate
Cat 0 (coastal area)	**1985**	Minimum thickness = 0,4 mm (30 gauge)	2 roofing nails per lath per CGS (penetration length = 45 mm)	**5 roofing nails per** lath per CGS (penetration length = 45 mm)	Maximum support reaction = 3483 N (781 lb) → possible choice: CS22	**Necessity to reduce the distance between rafters (0,60 m)** → Maximum vertical support reaction = 4329 N (971 lb) + Maximum horizontal support reaction = 121 N (27 lb) → possible choice: H10A
Cat II (rural)	1429	Minimum thickness = 0,4 mm (30 gauge)	2 roofing nails per lath per CGS (penetration length = 45 mm)	4 roofing nails per lath per CGS (penetration length = 45 mm)	Maximum support reaction = 3761 N (844 lb) → possible choice: CS22	Necessity to reduce the distance between rafters (0,90 m) → Maximum vertical support reaction = 4676 N (1049 lb) + Maximum horizontal support reaction = 130 N (29 lb) → possible choice: H10A
Cat III (sub-urban)	1016	Minimum thickness = 0,4 mm (30 gauge)	1 roofing nails per lath per CGS (penetration length = 45 mm)	3 roofing nails per lath per CGS (penetration length = 45 mm)	Maximum support reaction = 3566 N (800 lb) → possible choice: CS22 / H6	Maximum vertical support reaction = 4433 N (994 lb) + Maximum horizontal support reaction = 124 N (28 lb) → possible choice: H10A
Cat IV (urban)	953	Minimum thickness = 0,4 mm (30 gauge)	1 roofing nails per lath per CGS (penetration length = 45 mm)	3 roofing nails per lath per CGS (penetration length = 45 mm)	Maximum support reaction = 3343 N (750 lb) → possible choice: CS22 / H6	Maximum vertical support reaction = 4156 N (932 lb) + Maximum horizontal support reaction = 116 N (26 lb) → possible choice: H10A

7. Guiding Principles

→ Based on the case study calculations and analysis of the field tests derive some basic guiding principles to support decision making on the choice of roof shape, and amounts and quality of materials to use

	Category 0: wind speed ≤ 100 km/h (peak at 150 km/h)				Category 1: wind speed ≤ 150 km/h (peak at 209 km/h)				Category 3: wind speed ≤ 209 km/h (peak at 250 km/h)				
roof shapes	5°	15°	30°	45°	5°	15°	30°	45°	5°	15°	30°	45°	
hipped	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.45	0.6	0.6	0.6	distance laths
	1.2	1.2	1.2	1.2	0.9	0.9	0.6	0.6	0.45	0.45	0.4	0.4	distance rafters
	H10A	H10A	H10A	H10A	H14	H14	H10A	H10A	H14	H14	H14	H14	hurricane straps Rafter / top plate
	3	3	3	3	6	6	6	5	11	10	10	10	# roofing nails for the edges/m
	2	2	2	2	4	4	4	4	8	7	7	7	replace by # roofing screws
gable	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.45	0.6	0.6	0.6	distance laths
	1.2	1.2	1.2	1.2	0.9	0.9	0.9	0.6	0.45	0.45	0.45	0.4	distance rafters
	2H3/ H10A	2H3/ H10A	H10A	H10A	H14	H10A	H14	H10A	H14	H10A	H14	H14	hurricane straps Rafter / top plate
	3	3	3	3	6	5	5	5	11	8	9	9	# roofing nails for the edges/m
	2	2	2	2	4	3	3	3	7	6	6	6	# roofing screws for the edges/m
single-pitch	0.6	0.6			0.6	0.6			0.45				distance laths
	1.2	0.6			0.6	0.4			0.3				distance rafters
	H10A	2H4	*NONE*	*NONE*	H10A	2H4	*NONE*	*NONE*	H10A	*NONE*	*NONE*	*NONE*	hurricane straps Rafter / top plate
	4	5			7	8			10				# roofing nails for the edges/m
	3	3			5	5			7				# roofing screws for the edges/m

7. Guiding Principles

	Urban area	Suburban area / rural area protected by trees	Rural area with low vegetation	Coastal area
Single-pitch roof	5°< Pitch < 15° Very easy to build Require a lot of material → very costly Roofing screws recommended	5°< Pitch < 15° Very easy to build Require a lot of material → very costly Roofing screws recommended	Pitch = 5° Very easy to build Require a lot of material → very costly Roofing screws recommended	Pitch = 5° Very easy to build Require more material → extremely costly Roofing screws recommended
Gable roof	5°< Pitch < 45° Easy to build Average cost Roofing nails	5°< Pitch < 30° Easy to build Average cost Roofing nails Pitch = 45° Require a lot of material → very costly Roofing nails	Pitch = 5° Easy to build Require more material → extremely costly Roofing screws recommended 15°< Pitch < 45° Easy to build Require more material → extremely costly Roofing nails	Pitch = 5° Easy to build Require even more material → extremely costly Roofing screws necessary 15°< Pitch < 45° Easy to build Require more material → extremely costly Roofing screws recommended

7. Guiding Principles

"rating" from
0 = not feasible/recommendable to
5= best performance/cost ratio of the different roof types taking in to account the criteria:

- resistance to wind
- amount of material needed (implication on logistics/cost)
- complexity of construction (implication on cost & time)

(Distance between laths and rafters, number of nails/screws, types of hurricane straps)

for wind speed ≤ 209 km/h (peak at 250 km/h)

exposure situation	pitch	5°	15°	30°	45°
0 - coastal area	hipped roof	2	4	3	3
	gable roof	2	5	5	4
	single-pitch	1	0	0	0
	gambrel		5		
II - rural area with low vegetation	hipped roof	3	3	3	4
	gable roof	3	5	5	5
	single-pitch	1	0	0	0
	gambrel		5		
III - rural area protected by trees / suburban area	hipped roof	4	4	3	3
	gable roof	4	5	5	3
	single-pitch	2	1	0	0
	gambrel		5		
IV - urban area	hipped roof	3	4	4	4
	gable roof	3	5	5	5
	single-pitch	2	1	0	0
	gambrel		5		

Field-Test

Verify and complete the calculations with complementary field tests of different CGI and fixings, to identify the weakest elements.

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