The Development of Steel Plate Products in Taiwan- In the Case of Offshore Steel

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Outline

- Steel Structure in Taiwan
- Manufacturing Technology of High Strength, High Toughness Offshore Wind Power Structural Steel Plates
- Conclusion

C.S.C. Headquaters

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Steel Structure in Taiwan

Steel Structure Market in 2021

- **Crude steel** total production of Taiwan

  ～ **23 million tons / year**

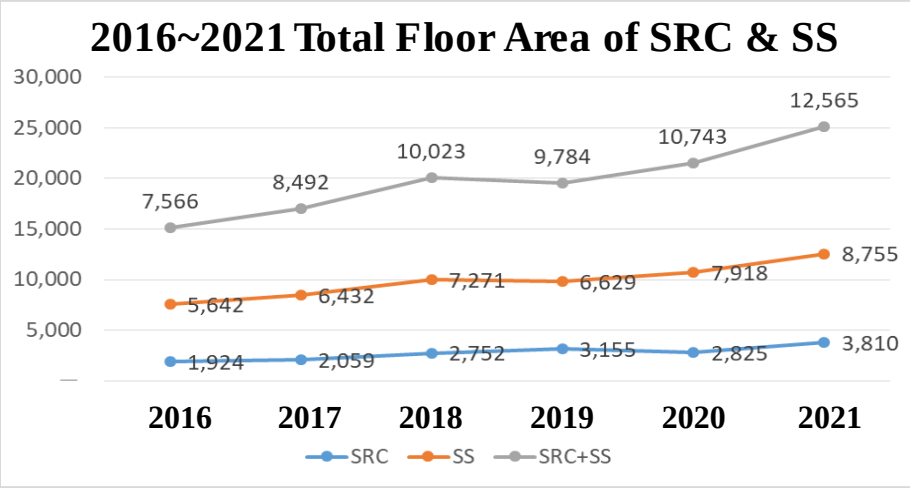
- Taiwan annual steel consumption of **construction**

  – **steel plate and rolling H section:**

    ～ **2 million tons / year**

  – **Rebar:**

    ～ **6 million tons / year**



- The total floor area of **SRC and SS** building licenses are growing in recent years.
- It is getting 20% higher from 2020 to 2021.

Steel Structure in Taiwan

Steel Structure → Green Material

✓1. Construction Steel

✓2. Bridge Steel

✓3. Offshore Steel

Steel Structure in Taiwan (cont.)

✓1. Construction Steel

- Crowded and limited space (to go vertically)

✓ The higher strength level of steel grade

- It makes the steel **material thinner** and the total weight of **structure lighter**.
- It **decrease the damage level of earthquake**.

- Height:508m
- Steel Usage:110,000MT
- **Material: SM570**

Construction Steel: SM570M

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✓ CSC designed SM570M steel grade with lower Ceq. higher and stricter mechanical properties, in order to fulfill the specification of seismic-resisting application。

Chemical Requirement	• Carbon equivalent content (Ceq) ≤ 0.46% • Crack susceptibility factor (Pcm) ≤ 0.29%
Yield Strength (MPa)	• 420~540 (No Upper Limit for JIS/CNS SM570)
Tensile Strength (MPa)	• 570~720
Y/T Ratio(%)	• ≤ 85 (No requirement for JIS/CNS SM570)
Elongation (%)	• ≥ 20 min
Charpy V-notch Test (J)	• t/4 ≥ 47J (-5℃) • t/2 ≥ 27J (-5℃) (No requirement for JIS/CNS SM570)
HAZ CVN(J) (SM570M CHW)	• Heat Input ≤ 880kJ/cm • t/2 ≥ 15J (-5℃)

Steel Structure in Taiwan (cont.)

✓2. Bridge Steel

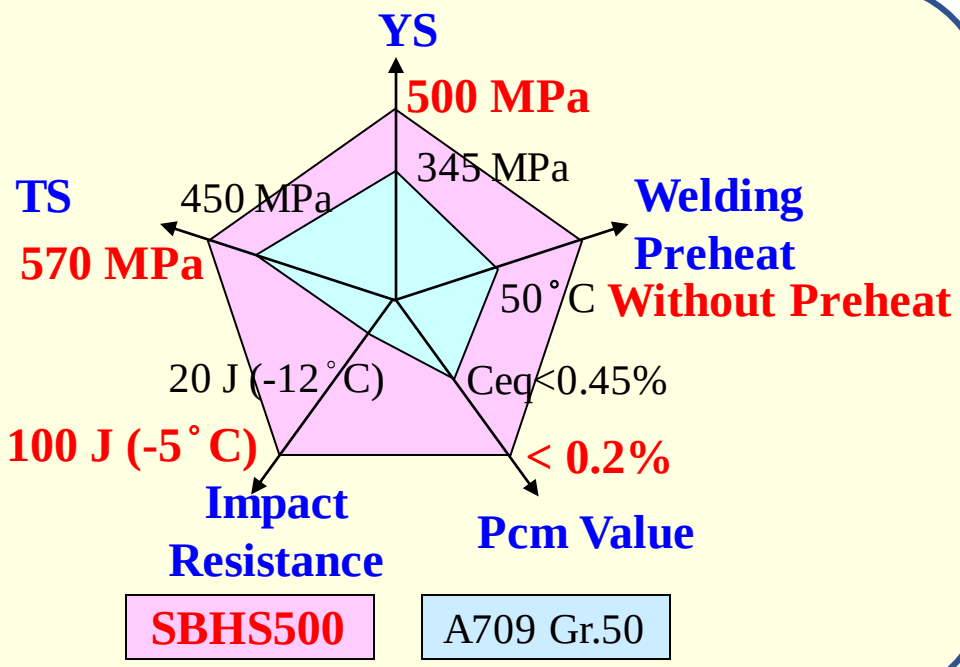
- Rapid climate change (to go horizontally)

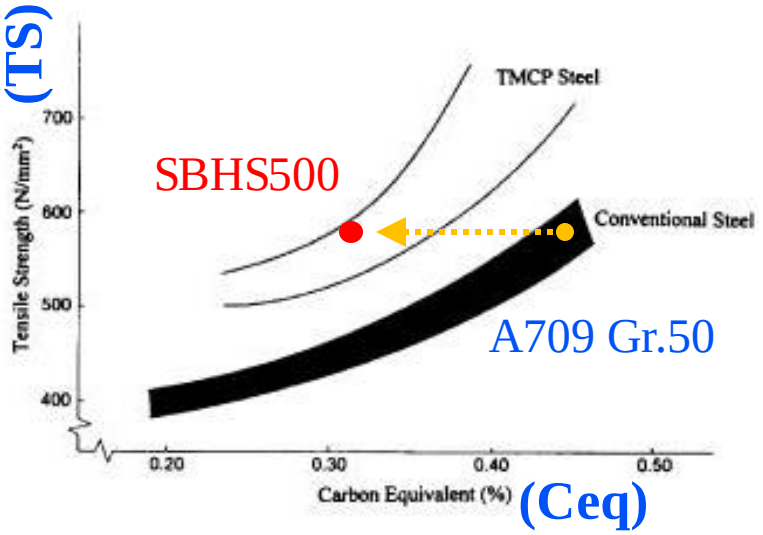
- 68 bridges in southern Taiwan were damaged after the serious typhoon Morakot attacked in 2009, **only 3 bridges which is made by steel-structure remained safe**.

✓The longer span of bridge is better

- **It lower the number of the bridge pier .**
- It **decrease the risk** of bridge pier being destroyed **by debris flood**.

Bridge Steel: 60kg SBHS500





✓ **Compare to the conventional bridge steel A709 Gr.50:**

1. **Higher Strength:** YS (345→500 MPa) is increased by 45%.
2. **Better Impact Resistance:** CVN 21℃ 27J→ -5℃ 100J
3. **Excellent Weldability- No preheating:** Ceq<0.45%→Pcm<0.2%

Steel Structure in Taiwan (cont.)

✓3. Offshore Steel

- Rising of the sea level (to go offshore)

✓Wind power generators

➢Taiwan government has planned to **establish 600 wind power generators in Taiwan strait**, in order to follow the **global trend** of energy and ecology protection strategy.

S.S. have been widely used in many industry.

Manufacturing Technology of High Strength, High Toughness Offshore Wind Power Structural Steel Plates

Demands of Offshore Steel

Enlarging Design

- Bigger
- Lighter
- Less Cost
- <High Strength>

Harsh Environment

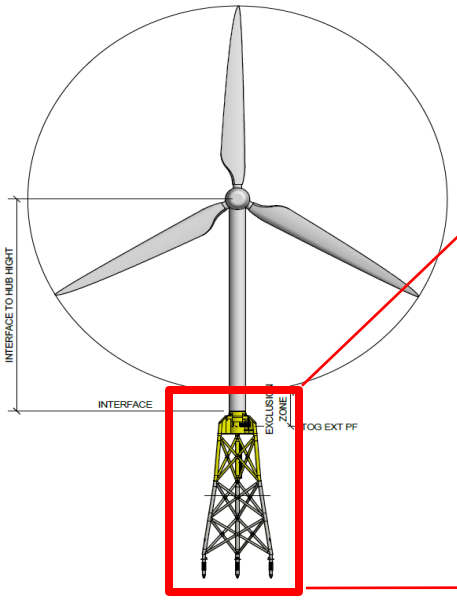
- Endurance of Wind, Wave, and Seismic Strikes
- Low Temperature
- Limited Maintenance Capability
- <Excellent Impact Resistance>

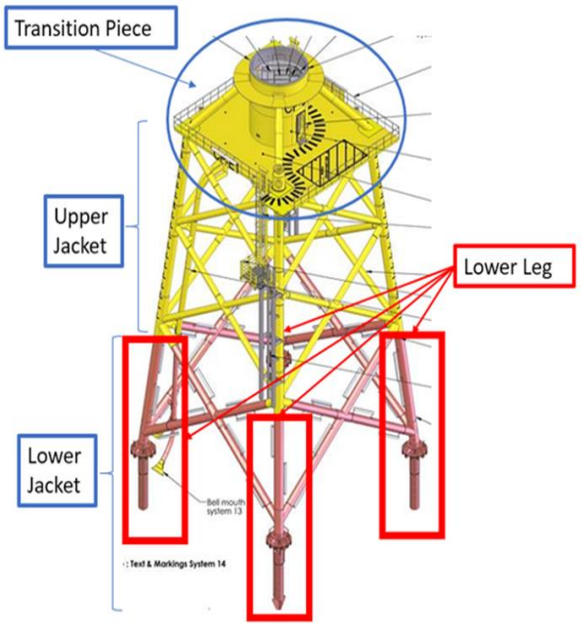
Faster Installation

- Shorter Project Lead Times
- Less Repairment after Welding
- <Better Weldability, Anti-Lamellar>

2025 Target: 5.5GW
(≒668 wind turbines)

Quality Requirements





Fan/ Tower/ **Foundation**

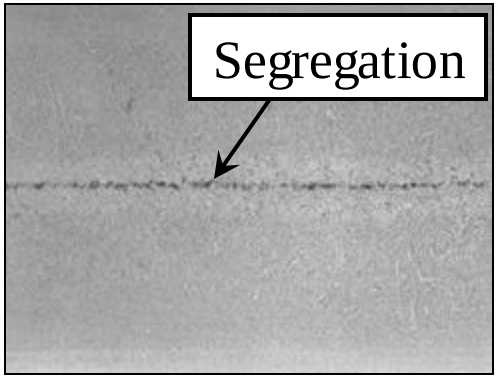
1200 ton/each
(66% of whole Wind Turbine)

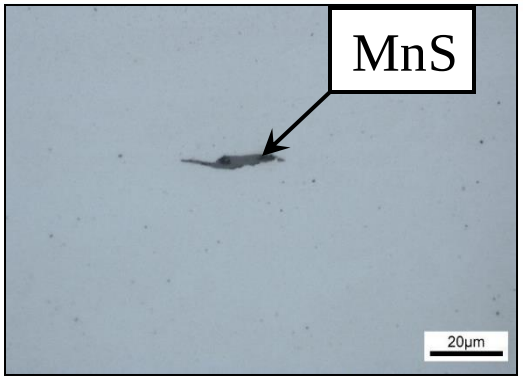
S355ML /S460ML Standard	Carbon Equivalency	YS (MPa)	TS (MPa)	El (%)	ZRA (%)	-40°C Impact Energy(J)
EN10025-4	**≦0.40** **≦0.47**	335 430	440~600 510~690	22 17	Z35	**Longitudinal≧31** **Transverse≧20**
CSC Specification	**≦0.35** **≦0.41**	335 430	440~600 510~690	22 17	Z35	**Longitudinal≧50** **Transverse≧50**

Quality Requirements(cont.)

✓ Ultra-low [P], [S]

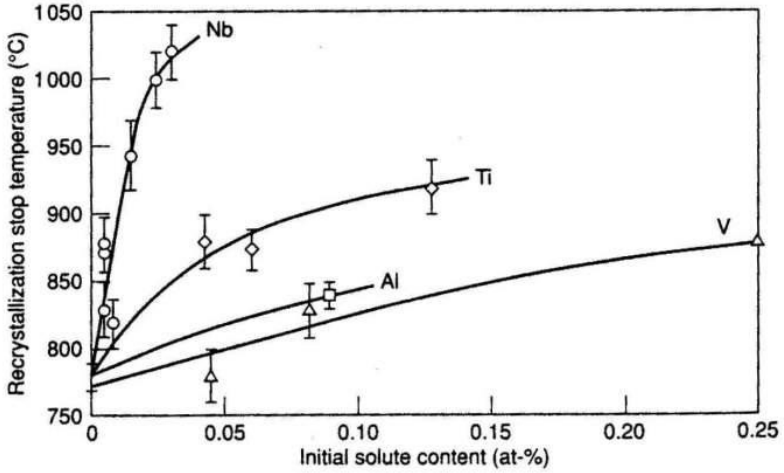
- ➢ Avoid deleterious inclusions
- ➢ Avoid center segregation





✓ Addition of Microalloys

- ➢ Recrystallization Stop Temperature: Nb >Ti >Al >V
  →Grain Refinement → Strength & Toughness



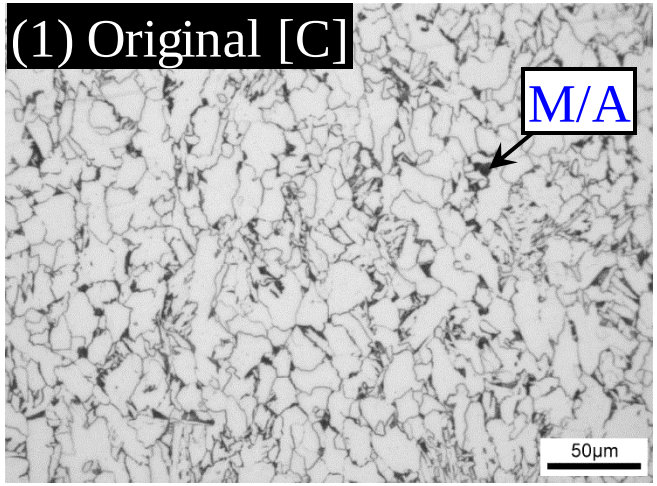
$$Tnr = 887 + 464\,C + (6445\,Nb - 644\,Nb^{1/2}) + 890\,Ti + 363\,Al + (732V - 230\,V^{1/2}) - 357\,Si$$

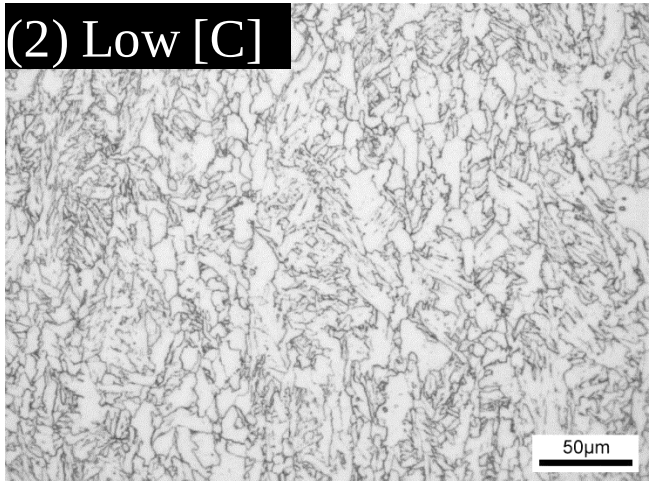
Quality Requirements(cont.)

✓ Low Carbon Content

- Less M/A →Less brittle texture
- The impact toughness was increased approximately by 30J in average.

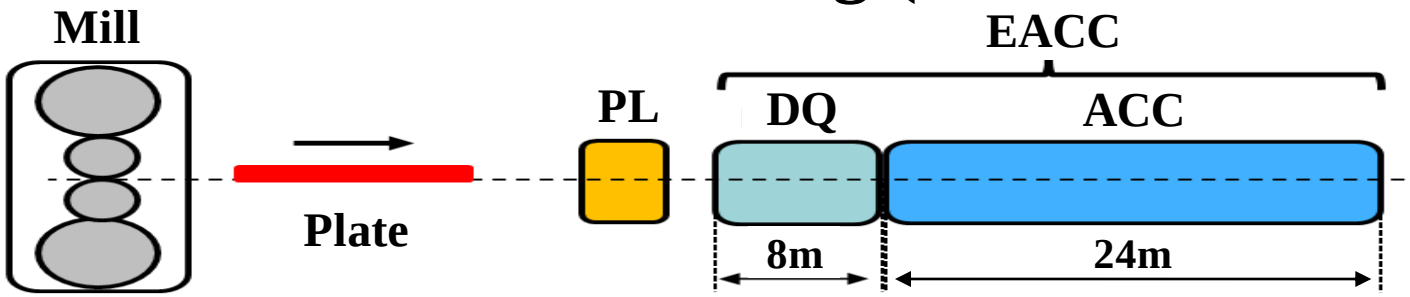
Content	Tensile Test			ZRA (%)	Temp -40°C Charpy Impact Energy (J)	
	TS (MPa)	YS (MPa)	EL (%)		Longitudinal	Transverse
Original	499	394	28	66	264	252
Low Carbon	495	387	31	71	299	285

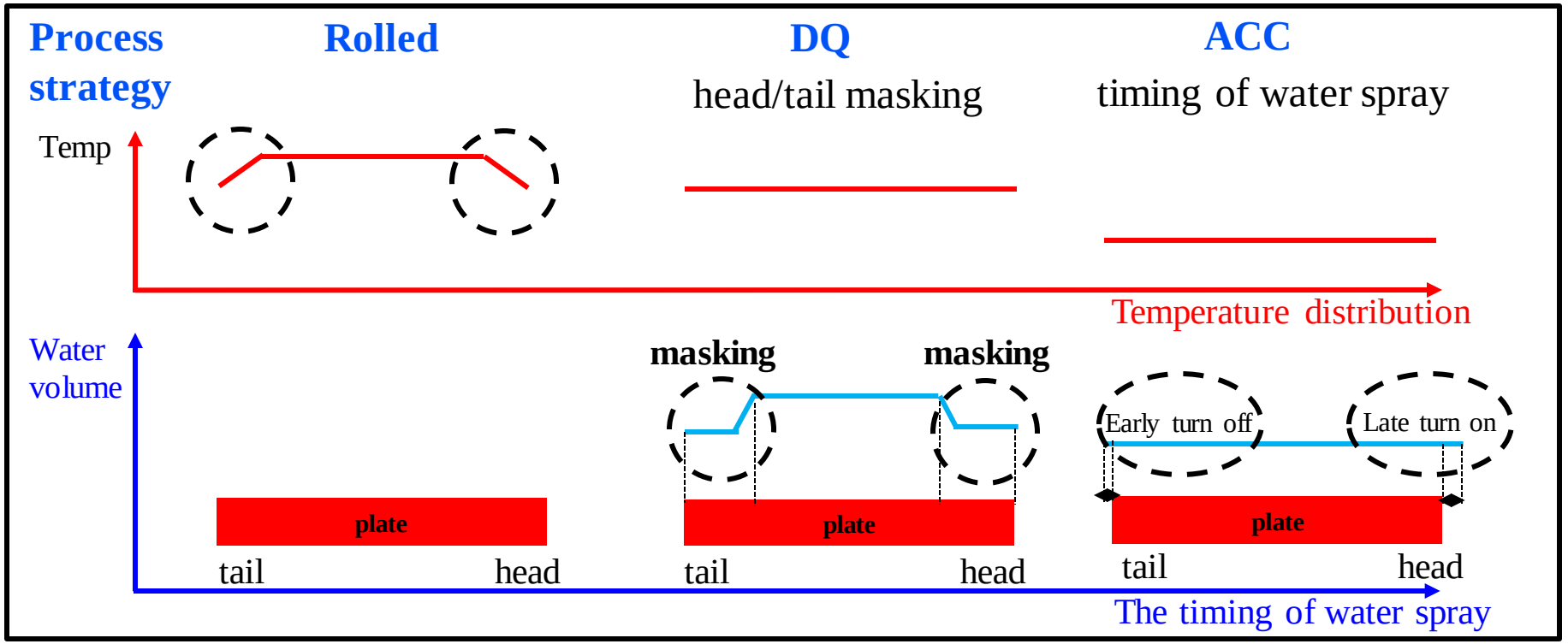




Cooling Technique

✓ Extended Accelerated Cooling (EACC)





Cooling Technique: EACC (cont.)

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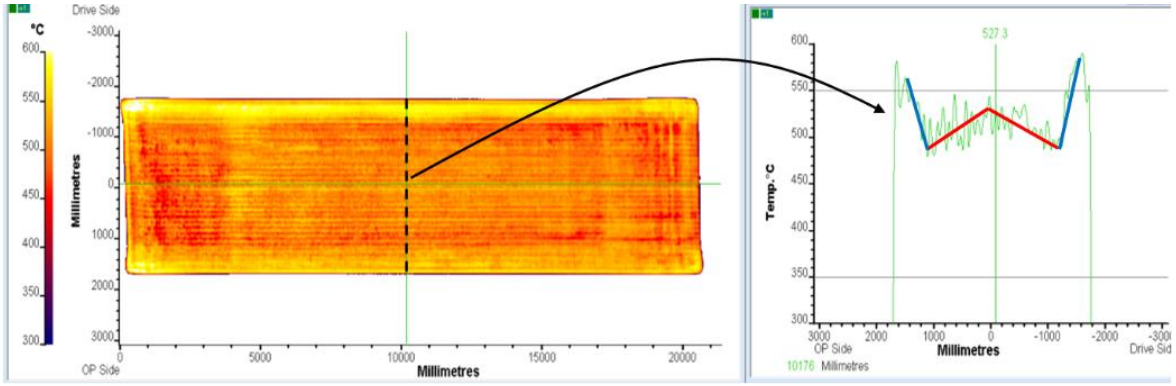
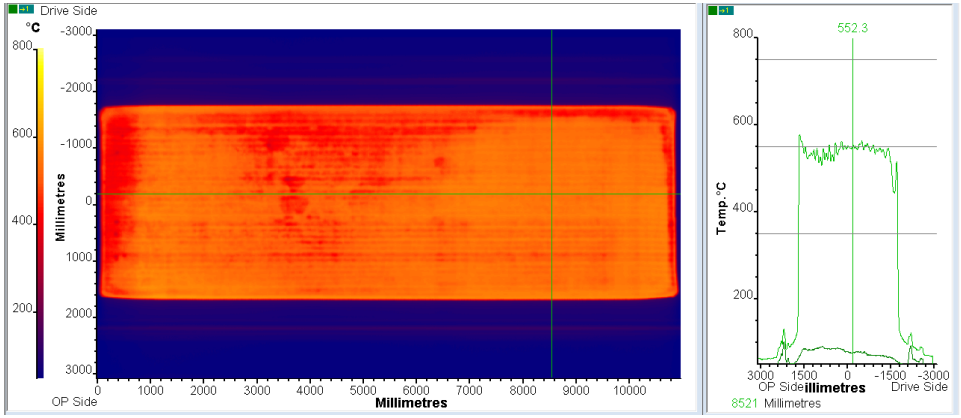
Temperature profile in following cooling process:

(a) ACC



(b)EACC



- Overcooling near head and edge portion were greatly resolved by EACC cooling system.

Summary

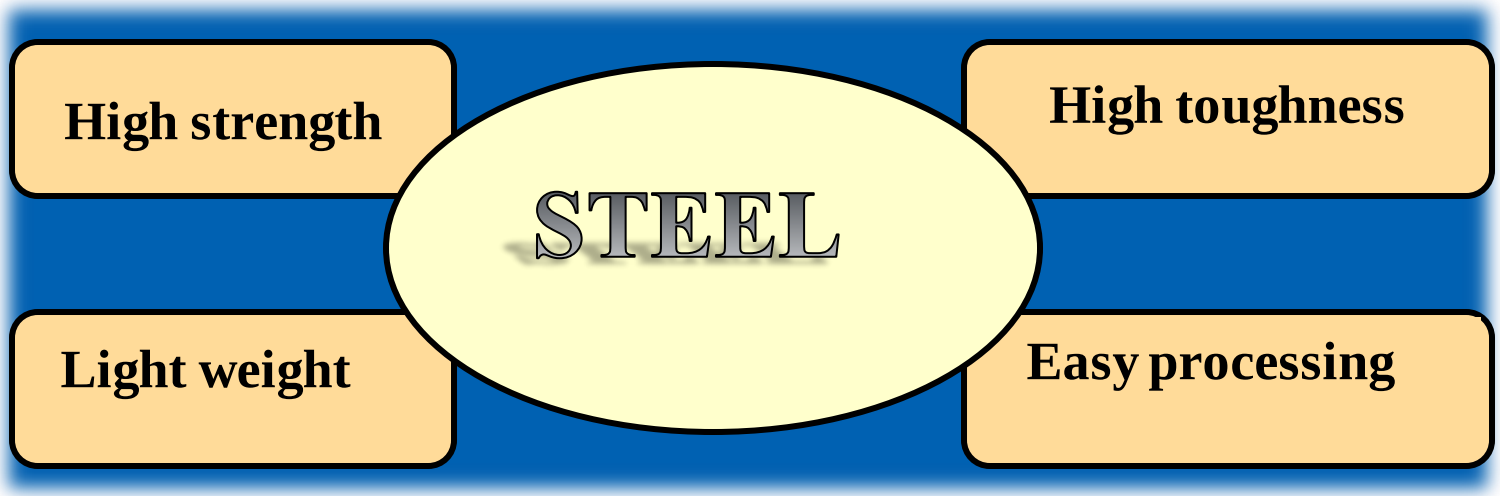
- ✓ After the implementations including control of [P], [S], addition of microalloys, reduction of carbon content, and production by EACC cooling system, offshore steel with stable quality and better performance has been developed.

- ✓ In 2021 July, Taiwan's first indigenous underwater foundation is built.

Conclusion

Conclusion

- Advantages of steel structure are short construction period and high seismic resistance.
- We emphasize on the quality of material, welding and testing technique.



Recent Landmark Steel Structures in Taiwan

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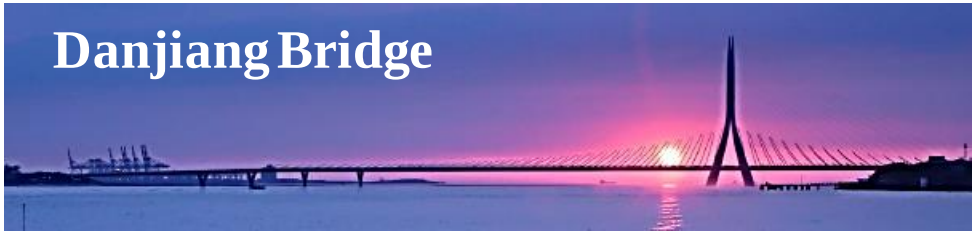
✓ **Danjiang Bridge**

Will be the longest single-tower, asymmetric cable-stayed bridge in the world.



- **Span: 450m**
- **Steel usage: 30,000t**
  - ✓A709 HPS70W(3.7%)
  - ✓A709 Gr.50W

✓ **Taipei Twin Towers：**

Will be the 2nd and 3rd highest building in Taiwan.

- **Height: 360 and 280m**
- **Steel usage: 130,000t**
  - ✓ SM570(80%)
  - ✓ SN490

Thank You for Your Attention!

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