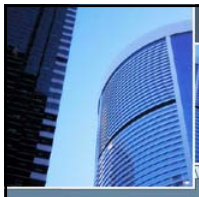
10 reasons to choose H

Dr Andrew Bond
Geocentrix

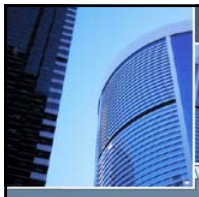


10 reasons to choose H

1. H is adaptable
2. H is advantageous
3. H is cost-effective
4. H is durable
5. H is efficient
6. H is quality
7. H is silent
8. H is sustainable
9. H is water-proof
10. H is well-supported

1. H is adaptable

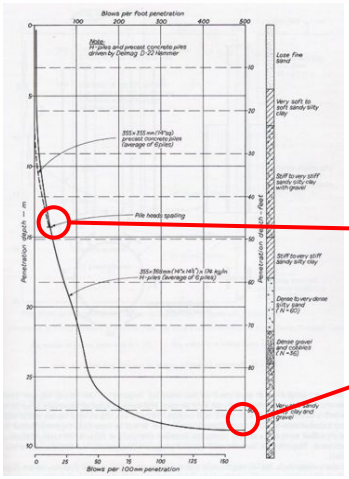
10 reasons to choose H



Adaptability of driven steel H-piles

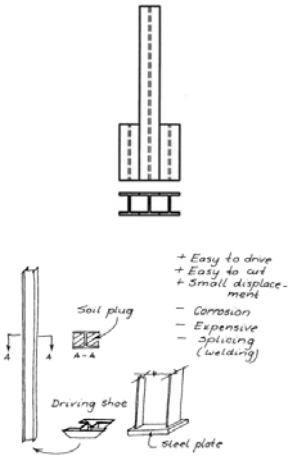
- “Steel piles [are] robust, light to handle, capable of carrying high compressive loads when driven on to a hard stratum, and capable of being driven hard to a deep penetration to reach a bearing stratum or to develop a high skin-frictional resistance.
- “H-section piles … are suitable for driving in groups at close centres … to avoid substantial ground heave or lateral displacement.
- “They can withstand hard driving and are useful for penetrating … cemented layers and for punching into rock.”
  - Tomlinson, reference [1] pp24

Steel H-piles vs concrete box piles



- Hartlepools Nuclear Power Station
  - Reference [1]
- Glacial clays, sands, and gravels
- Pre-cast concrete piles
  - 355 mm x 355 mm box
  - Refused at 14.9m
  - Failed at loads of 1.1-1.5 MN
- Steel H-piles
  - 355 mm x 368 mm x 174 kg/m
  - Driven to 29m
  - Loaded to 3 MN without failing

Adapting H-piles



- Enhanced end-bearing
  - Weld short H-sections onto flanges of piles near their toe [1]
- Enhanced shaft friction
  - End plates ensure soil plug is formed [7]
- Prevent damage on driving
  - Use driving shoes [7]

2. H is advantageous

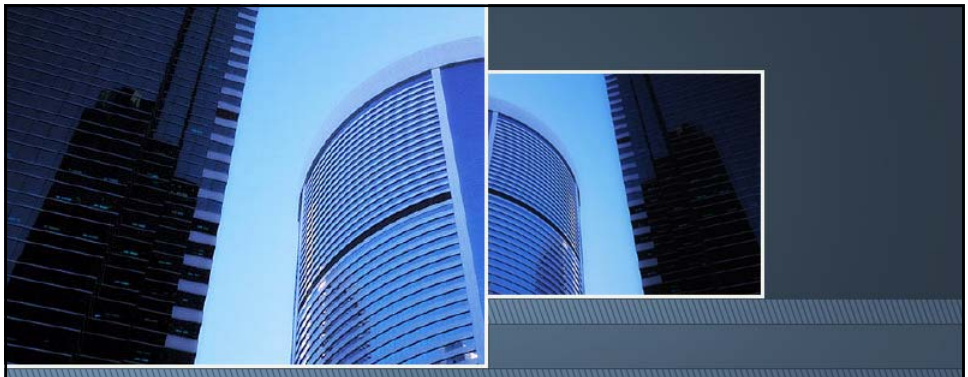
10 reasons to choose H

Advantages of driven displacement piles

1. Material forming pile can be inspected for quality and soundness before driving
2. Not liable to squeezing or necking
3. Construction operations not affected by ground water
4. Projection above ground level advantageous to marine structures
5. Can be driven in very long lengths
6. Can be designed to withstand high bending and tensile stresses
   - Tomlinson, ref. [1] pp48

Disadvantages of bored-cast-in-place replacement piles

1. Concrete in shaft liable to squeezing or necking in soft soils when conventional types used
2. Special techniques needed for concreting in water-bearing soils
3. Concrete cannot be inspected after installation
4. Enlarged bases cannot be formed in cohesionless soils
5. Cannot be extended above ground level without special adaptation
6. Low end-bearing resistance in cohesionless soils due to loosening by conventional drilling operations
7. Drilling a number of piles in group can cause loss of ground and settlement of adjacent structures
   - Tomlinson, ref. [1] pp49



3. H is cost-effective

10 reasons to choose H

H is cost-effective

- Pay only for what you need
- High structural strength > increased working loads > fewer piles
- Transportation cost of materials to site
  - volume and weight of steel about 1/3rd concrete
  - in-situ concrete piles also need re-bars
- No added expenses for site clean-up
  - haulage cost of “muck-away” for CFA and bored piles
  - rising landfill taxes will increase this cost
  - piling in contaminated land further increases this cost
- Dereliction cost of using concrete

Installing 4000 x 36m long H-piles in Indiana, USA[9]

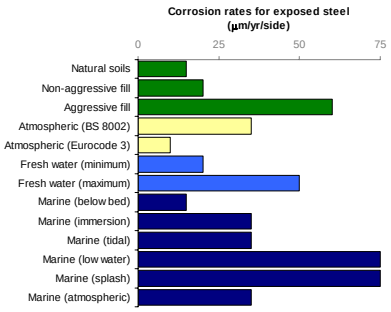
4. H is durable

10 reasons to choose H

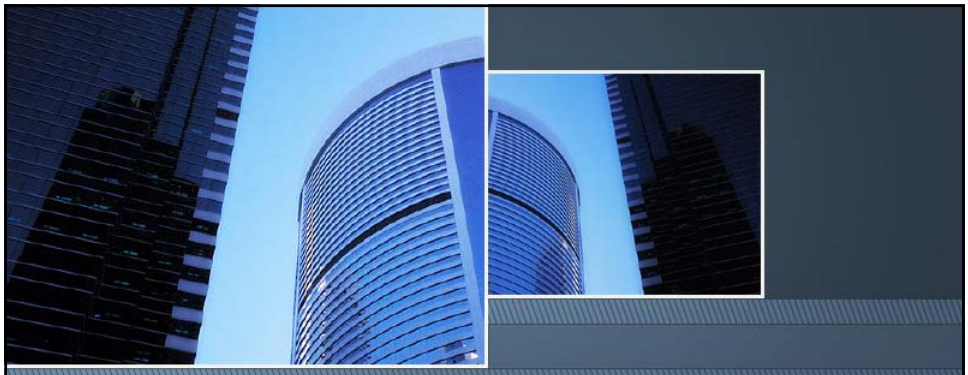
Steel piles have a long life

- "Steel piles have a long life in ordinary soil conditions if they are completely embedded in undisturbed soil"
  - "…portions … exposed to sea water or to disturbed soil must be protected against corrosion by cathodic means…"
- "[Timber piles] decay above ground-water level, and in marine structures … suffer damage by destructive mollusc-type organisms"
- "Cast-in-place concrete piles are not so resistant to aggressive substances because of … [incomplete] compaction
  - "Protection can be provided [by] permanent linings of coated light-gauge metal or plastics"
- Tomlinson, ref. [1] p9

Corrosion protection



- Corrosion rates for exposed steel
  - British Standards (BS 8002, BS 8004, and BS 6349)
  - Eurocode 3 (EN 1993-5)
- Methods of increasing effective life
  - heavier section
  - high yield steel
  - organic coatings
  - cathodic protection
  - concrete encasement
- Corus, ref. [5]

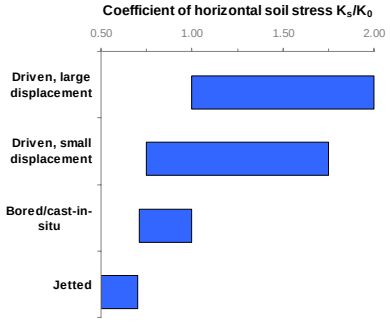


5. H is efficient

10 reasons to choose H

Bearing resistance of piles

- Total resistance
  $R_d = R_b + R_s$
- Base resistance
  $R_b = q_b A_b$
  - Undrained: $q_b = N_c C_u + \sigma_v$
  - Drained: $q_b = q_b = N_q \sigma'_v$
- Shaft resistance
  $R_s = \Sigma (f_s dA_s)$
  - Undrained: $f_s = \alpha C_u$
  - Drained: $f_s = K_s \sigma'_v \tan \delta = \beta \sigma'_v$



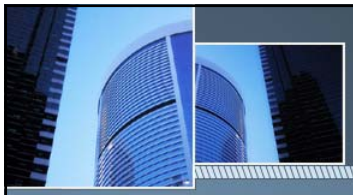
Partial resistance factors from Eurocode 7

- Eurocode 7 specifies partial factors for different pile types, ref. [8]
- Factors reflect how much of ultimate resistance is mobilised at working loads

Partial resistance factor γ_R (set R4 for use with DA1)		Pile type		
		Driven	CFA	Bored
Compression	Base	1.3	1.45	1.6
	Shaft	1.3	1.3	1.3
	Overall	1.3	1.4	1.5
Tension	Shaft	1.6	1.6	1.6
Angle of interface friction δ		0.67ϕ	ϕ	ϕ

6. H is quality

10 reasons to choose H

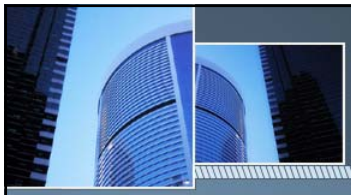


H is quality

- Quality is consistent from the first pile to the last
- Steel piles maintain their shape during installation
  - No bulging in soft ground
  - Not damaged by subsequent piles
- Dynamic inspection verifies integrity
- Static or dynamic testing confirms load-carrying capacity

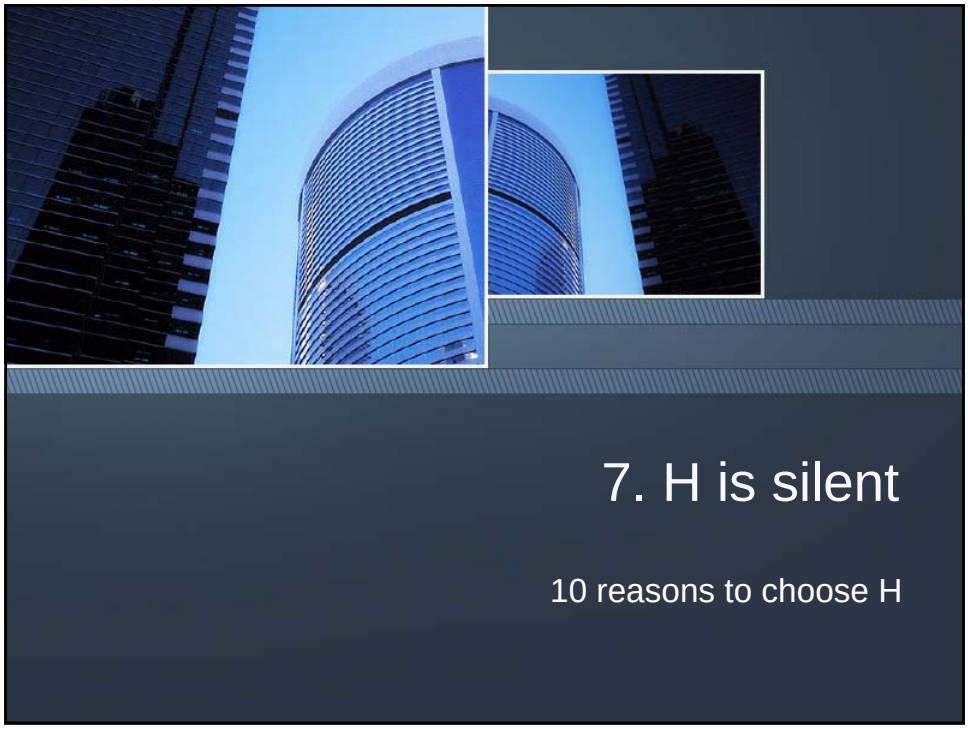
Defects in displacement piles from driving [ref. 3]

Problem	Steel piles	Concrete piles
Damaged pile head	1. Unsuitable hammer weight 2. Incorrect use of dollies, helmets, packing 3. Overdriving 4. Rough cutting of pile ends	*As for steel 1-4, PLUS…* 5. Unsuitable reinforcement details 6. Insufficient reinforcement 7. Poor quality concrete 8. Inadequate concrete cover
Damaged pile shaft	1. Unsuitable hammer weight 2. Overdriving 3. Obstructions 4. Inadequate directional control	*As for steel 1-3, PLUS…* 4. Excessive restraint on piles during driving 5. Poor quality concrete 6. Inadequate or incorrect concrete cover 7. Incorrect use of dollies, helmets, packing
Damaged pile toe	1. Overdriving 2. Obstructions 3. Difficulty of toeing into rock	*As for steel 1-2, PLUS…* 3. Poor quality concrete 4. Insufficient reinforcement 5. Inadequate or incorrect concrete cover 6. Absence of rock show



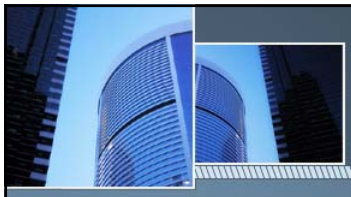
Defects in replacement piles [ref. 3]

Area	Defect	Area	Defect
Debris	1. Soil or debris embedded in concrete near top of pile 2. Soil or rock debris at base 3. Debris embedded in shaft 4. Inclusion of clay lumps within pile shaft	Concrete	1. Dilution of cement paste and formation of soft cement paste 2. Excessive bleeding of water from exposed surface at top of pile 3. Weak and partially segregated concrete near pile base 4. Occasional segregation of concrete in pile shaft 5. Segregation of concrete with dilution of cement paste and formation of soft cement paste (sometimes layers of sand and gravel are found with pile body) 6. Disintegration of concrete
Shape	1. Hollow on surface with small bulbous projection below 2. Discontinuity with large bulbous projection below 3. Local reduction in diameter (necking) with bulbs below 4. Necking without bulbs below 5. Discontinuities 6. Distortion 7.Containment of concrete within cage leading to lack of cover to reinforcement or lack of concrete in bell-out 8. Collapse of reinforcement cage		

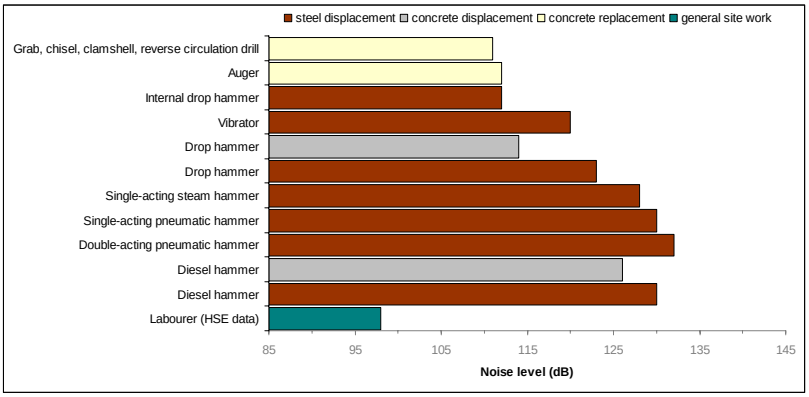


7. H is silent

10 reasons to choose H



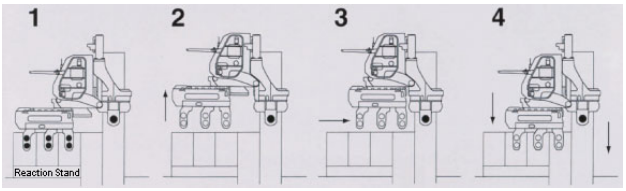
Noise levels for different pile hammers [ref. 3]



Steel piles without noise or vibration

- "A major obstacle to using steel in the past has been the perception that steel piles means driven piles, which equals noise and vibration nuisance.
- "That perception is out of date.
- "…a new generation of hydraulically powered equipment … can install high capacity steel piles without noise or vibration."
  - Robin Dawson, ref [4]

Silent piling



- Giken Silent Piler (H Piler) / Tosa Still Worker
  - maximum force: 1500 kN installation, 1500 kN extraction
  - speed: pressing-in 2-23 m/min, drawing out 2-28 m/min
  - weight: 9.5-12.8 tonnes
  - noise levels 60 dBA

Controlling noise[9]

8. H is sustainable

10 reasons to choose H

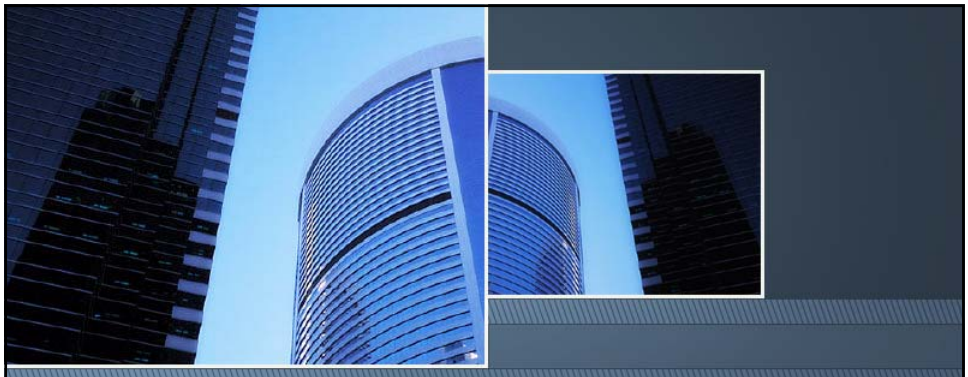
An environmental catastrophe

- "[The] apparent merits [of continuous flight auger piles] overlook an environmental catastrophe.
- "Redundant concrete piles cannot be removed [so] that the site is returned to its original condition. If they are removed by drilling the cost is far higher than installation, it produces low-grade aggregate of negative value and leaves a hole in the ground where the pile was.
- "This form of construction needs to be changed as soon as possible in order prevent further contamination or permanent dereliction"
  - Dawson, ref [6]

Extracting H-piles[9]

Removal of steel piles is straightforward

- "Removal of steel piles when a site is redeveloped – increasingly that is going to be every 30 years or so for buildings – is much more straightforward than their concrete counterparts."
  - Robin Dawson, ref. [4]
- "Steel can accommodate … high tensile forces on removal [and] will also last indefinitely in the oxygen-free environment beneath a structure"
  - Robin Dawson, ref. [6]

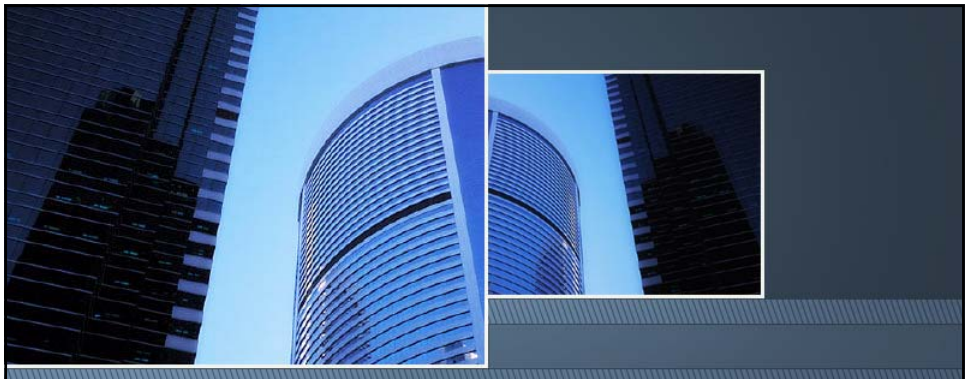


9. H is water-proof

10 reasons to choose H

Problems with driven cast-in-place piles from groundwater[3]

Problems	Causes	Remedial measures
Water ingress during driving casing and subsequent difficulties in concreting	Loss of shoe or base plate during driving	Replug with concrete and drive on
	Failure of welds or joints of tube	None
	Failure of seal on joints	None
	Cracking of casing sections because of incorrect distribution of driving stresses	None
Bulging of pile and associated waisting above	Soft ground conditions (c_u < 15 kPa). Displacement of ground under hydrostatic head of concrete	None
Water ingress causing softening of the base	Water-bearing sands and gravels	May be necessary to re-drive another pile through the faulty pile



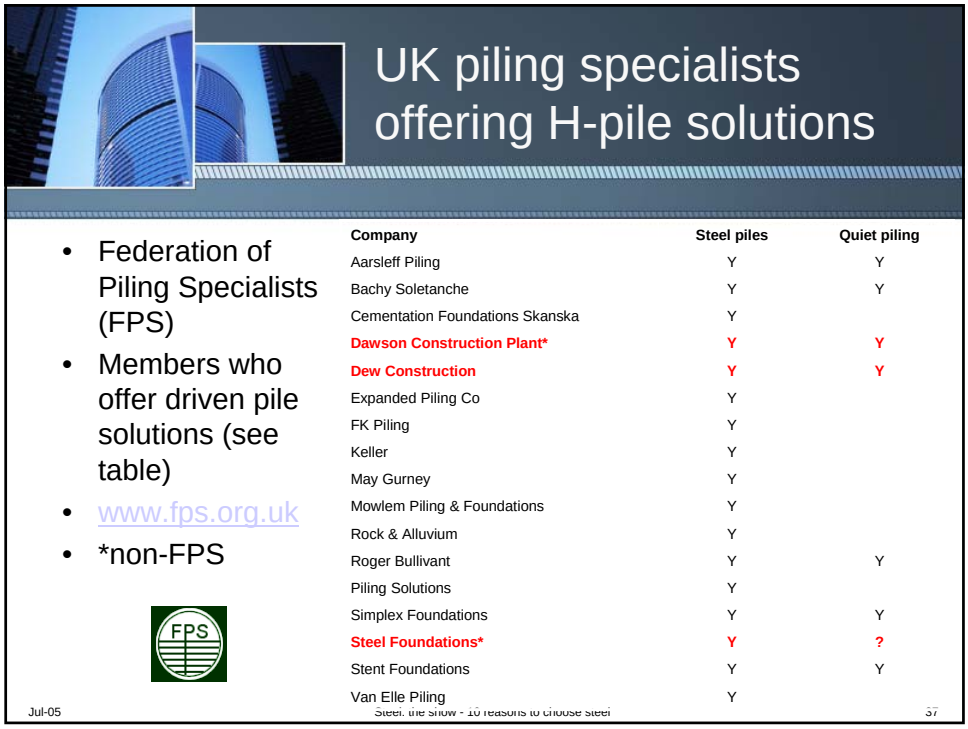
10. H is well-supported

10 reasons to choose H

Publications on driven piles

Software for pile design

- Repute
  - version 1 released 2002
  - design of pile groups
  - used by 10 of the top 20 UK consultants
  - version 2 under development (will add single pile design)
  - visit www.geocentrix.co.uk
- Corus Special Edition
  - commissioned by Corus to support design of steel H piles
  - based on Repute 2


UK piling specialists offering H-pile solutions
• Federation of Piling Specialists (FPS)
• Members who offer driven pile solutions (see table)
• www.fps.org.uk
• *non-FPS
FPS
Company | Steel piles | Quiet piling
Aarsleff Piling | Y | Y
Bachy Soletanche | Y | Y
Cementation Foundations Skanska | Y
Dawson Construction Plant* | Y | Y
Dew Construction | Y | Y
Expanded Piling Co | Y
FK Piling | Y
Keller | Y
May Gurney | Y
Mowlem Piling & Foundations | Y
Rock & Alluvium | Y
Roger Bullivant | Y | Y
Piling Solutions | Y
Simplex Foundations | Y | Y
Steel Foundations* | Y | ?
Stent Foundations | Y | Y
Van Elle Piling | Y
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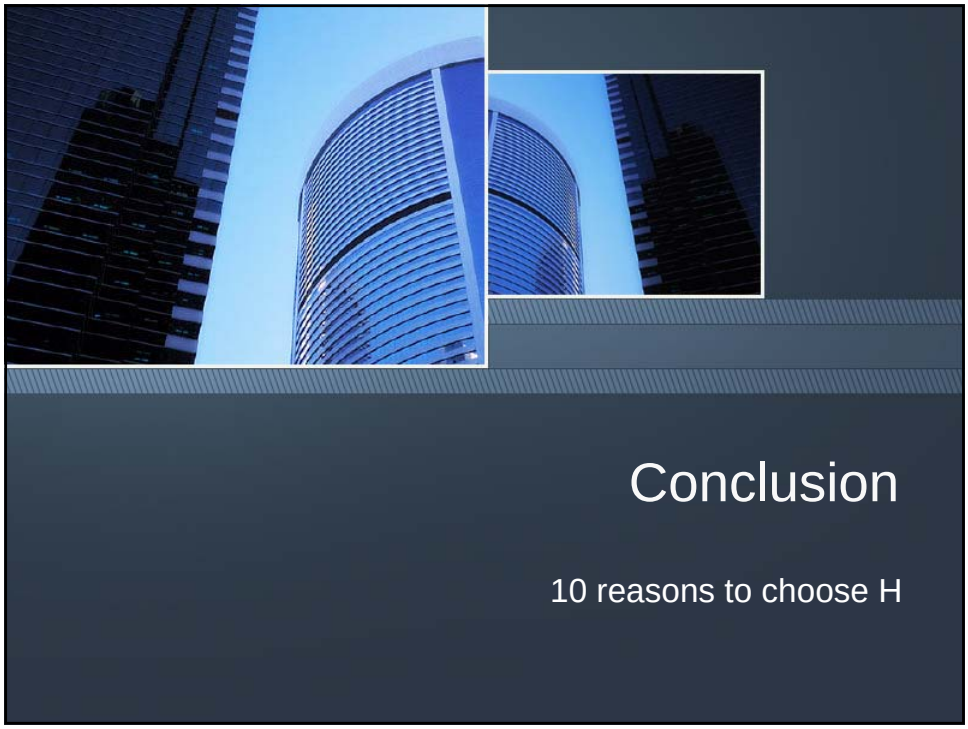
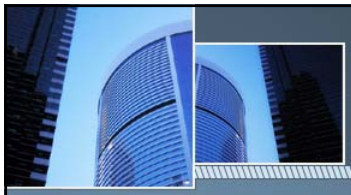

Conclusion
10 reasons to choose H

“Steel can now be reliably considered”

- “A lot of people still think that concrete is the only alternative, but … that is far from the case.
- “…you want quick installation of piles and the ability to build off them straight away with no delays
- “…you don’t want … to leave your concrete piles behind in the ground for another generation to deal with
  - Dawson, ref [4]



Driven piles are tested piles

“Driven piles are tested piles”

Pile Driving Contractors Association (USA)

www.piledrivers.org

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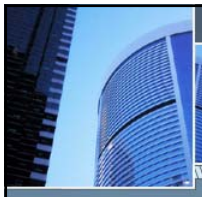
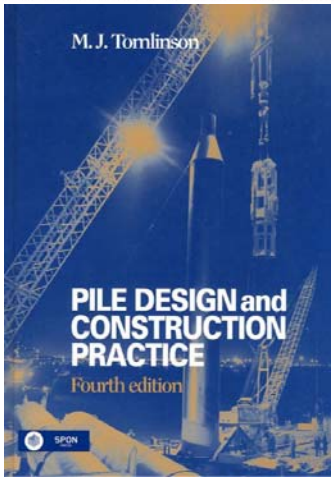
Download this presentation from:
www.geocentrix.co.uk/lectures/steel-the-show

References

10 reasons to choose H

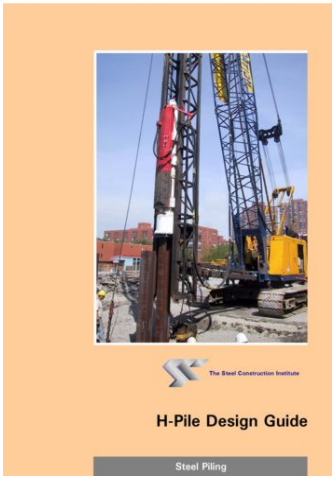


[1] Pile design and construction practice



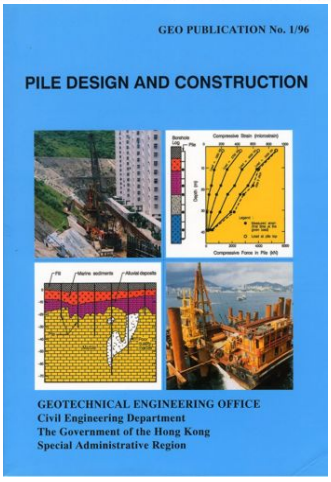
- Pile design and construction practice
  - By M.J. Tomlinson
  - 4th edition, 411pp
  - Spon Press (1994)
- Relevant sections
  - §2.2 Driven displacement piles
  - §3.1 Equipment for driven piles
  - §8 Piling for marine structures
  - §10 The durability of piled foundations

[2] H pile design guide



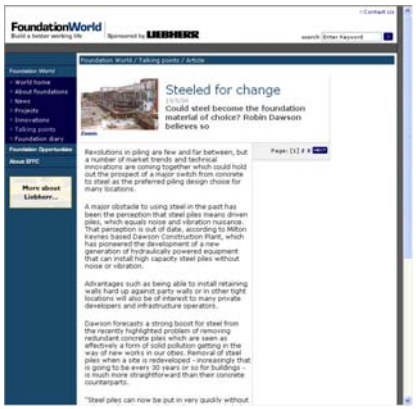
- H piles design guide
  - by A.R. Biddle
  - SCI-P335, approx. 109pp
  - Steel Construction Institute (2005, in preparation)
- Relevant sections
  - §1.2 Why choose steel piling?
  - §7 The installation and testing of steel bearing piles
  - §8 Economic design
  - §10 Corrosion and protection of steel piles

[3] Pile design and construction



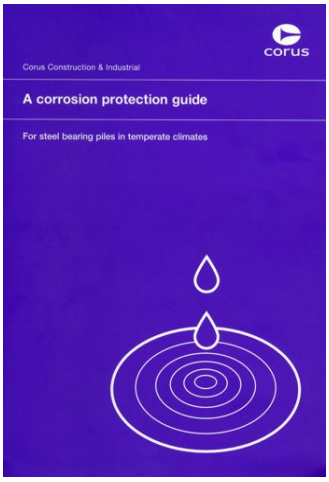
- Pile design and construction
  - by Geotechnical Engineering Office
  - GEO 1/96, 348pp
  - Government of Hong Kong Special Administrative Region (1996)
- Relevant sections
  - §3.3 Small displacement piles
  - §4.2 Factors to be considered in choice of pile type
  - §7.2 Installation of displacement piles

[4] Steeled for change



- Steeled for changed
  - by Robin Dawson (Dawson Construction Plant)
  - 3pp Talking Point article
  - Foundation World (19/08/2004)
  - www.foundationworld.org.uk

[5] A corrosion protection guide



- A corrosion protection guide
  - 8pp brochure
  - Corus Construction & Industrial (2005)

References [6]-[9]

- [6] Foundation piling – steel to replace concrete
  - by R. Dawson
  - Geotechnical Engineering 149, October 2001, Issue 4, pp205-07
- [7] Foundation Engineering
  - by Prof. Bengt B. Broms
  - www.geoforum.com
- [8] EN 1997-1 Eurocode 7: Geotechnical design – Part 1: Generl rules
- [9] Pictures courtesy Dawson Construction Plant Ltd